

From the Lab to the Marketplace to Standards SLAC Colloquium

February 5, 2007

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or just Google “Art Rosenfeld”

The Economist

JANUARY 27TH-FEBRUARY 2ND 2009 www.economist.com

Shake-up in Big Pharma

China's space blast

Europe's rotating slump

Serbia's encouraging election

Hating Hillary Clinton



The greening of America

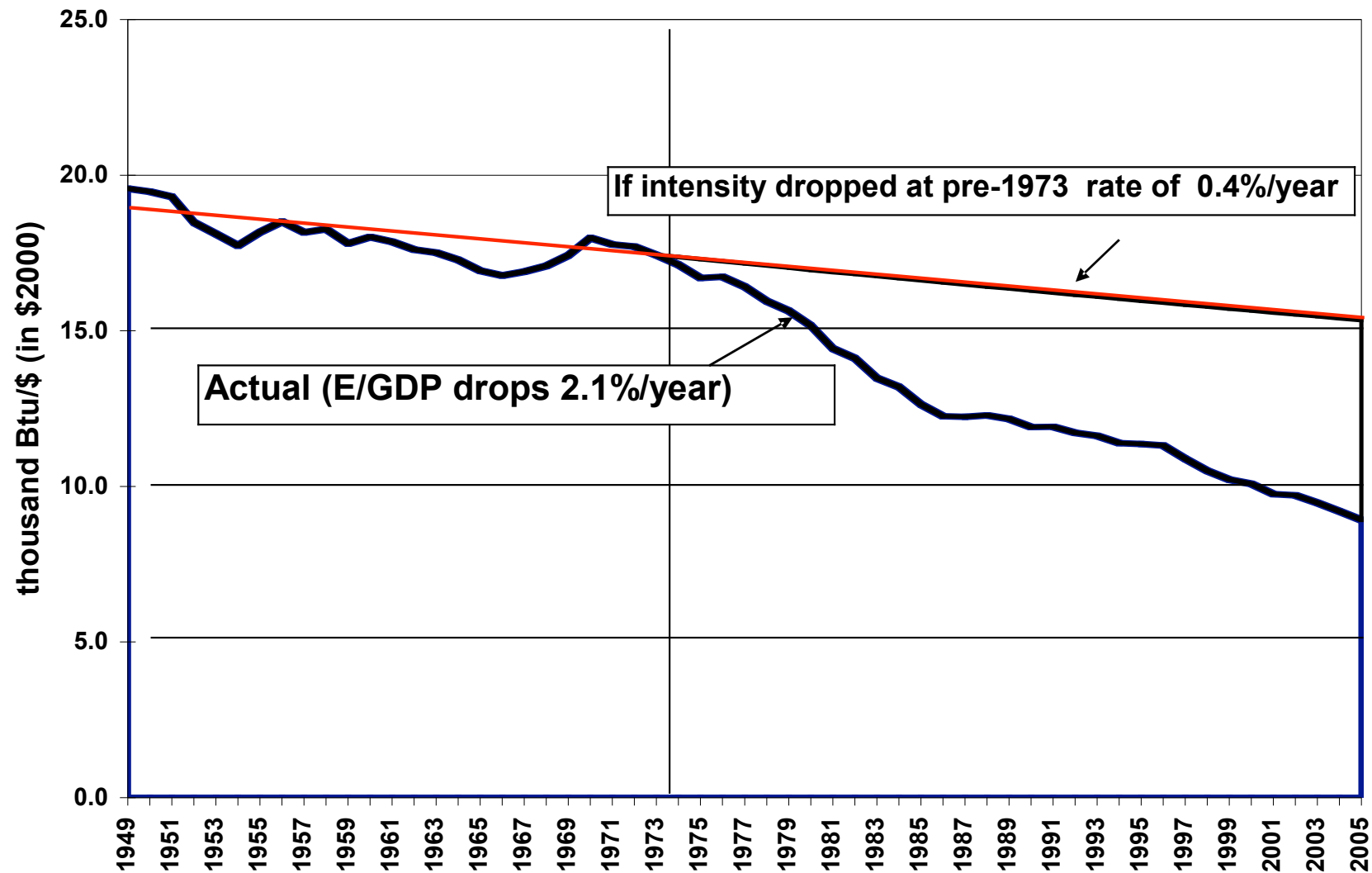
1949

Rosenfeld

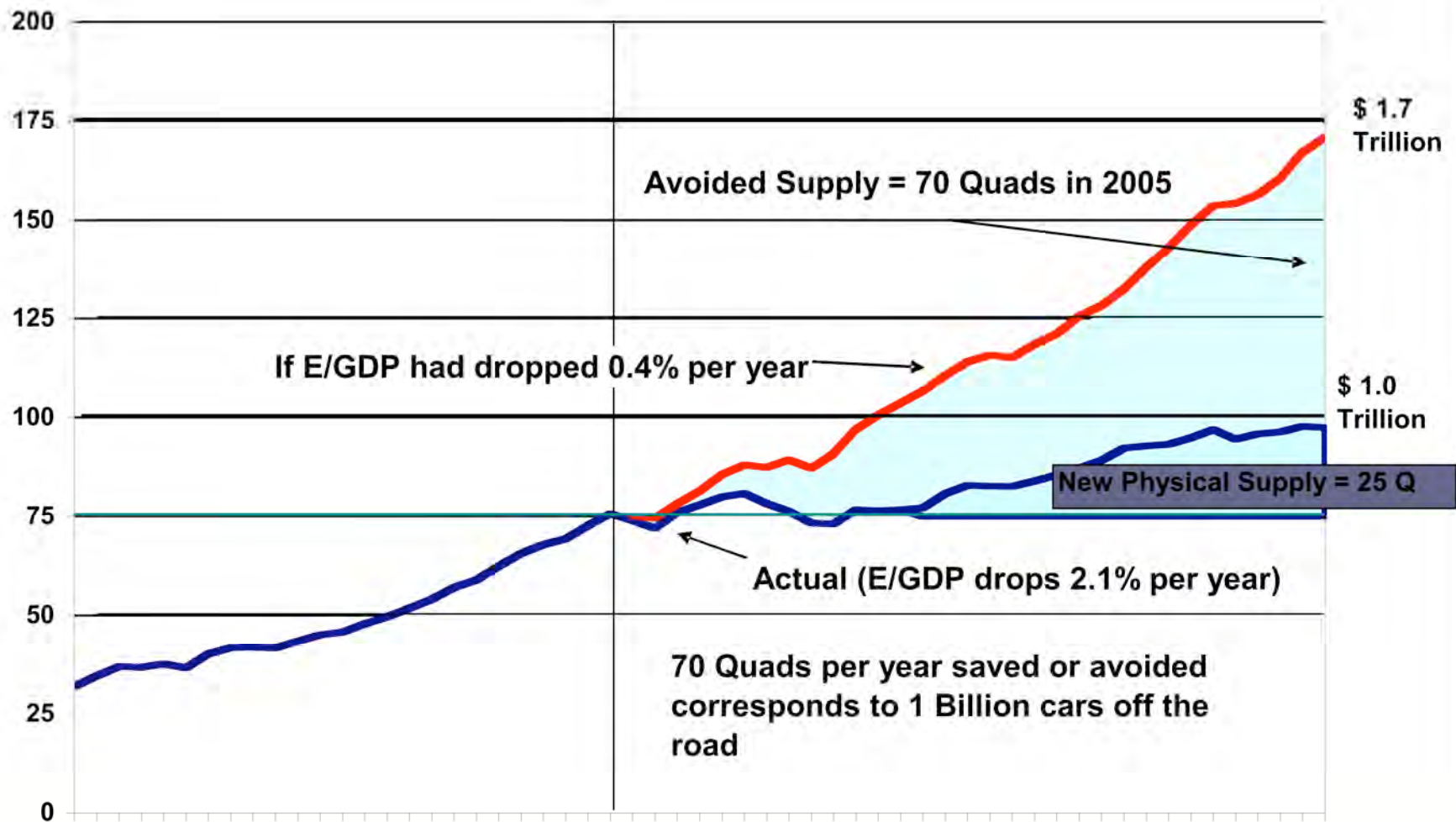
Nuclear Physics

A Course Given by **ENRICO FERMI**
at the University of Chicago. Notes Compiled by
Jay Orear, A. H. Rosenfeld, and R. A. Schluter

Energy Intensity in the United States 1949 - 2005



Energy Consumption in the United States 1949 - 2005



Environmental Equivalent of Avoiding 70 Quads

- ◆ 70 Quads = 33 Mbod (Million barrels of oil per day)
= 40% of World oil production of 80 Mbod
- ◆ 70 Quads = 1 Billion cars off the road, impressive since there are only 600 million cars on the road

How Much of The Savings Come from Efficiency?

- ◆ Easiest to tease out is cars
 - In the early 1970s, only 14 miles per gallons
 - Now about 21 miles per gallon
 - If still at 14 mpg, we'd consume **75 billion gallons more** and pay **\$225 Billion more** at 2006 prices
 - But we still pay **\$450 Billion per year**
 - If California wins the “Schwarzenegger-Pavley” suit, and it is implemented nationwide, we'll save **another \$150 Billion per year**
- ◆ Commercial Aviation improvements save another **\$50 Billion per year**
- ◆ Appliances and Buildings are more complex
 - We must sort out true efficiency gains vs. structural changes (from smokestack to service economy).

How Much of The Savings Come from Efficiency (cont'd)?

- ◆ Some examples of estimated savings in 2006 based on 1974 efficiencies minus 2006 efficiencies

	Billion \$
Space Heating	40
Air Conditioning	30
Refrigerators	15
Fluorescent Tube Lamps	5
Compact Fluorescent Lamps	5
Total	95

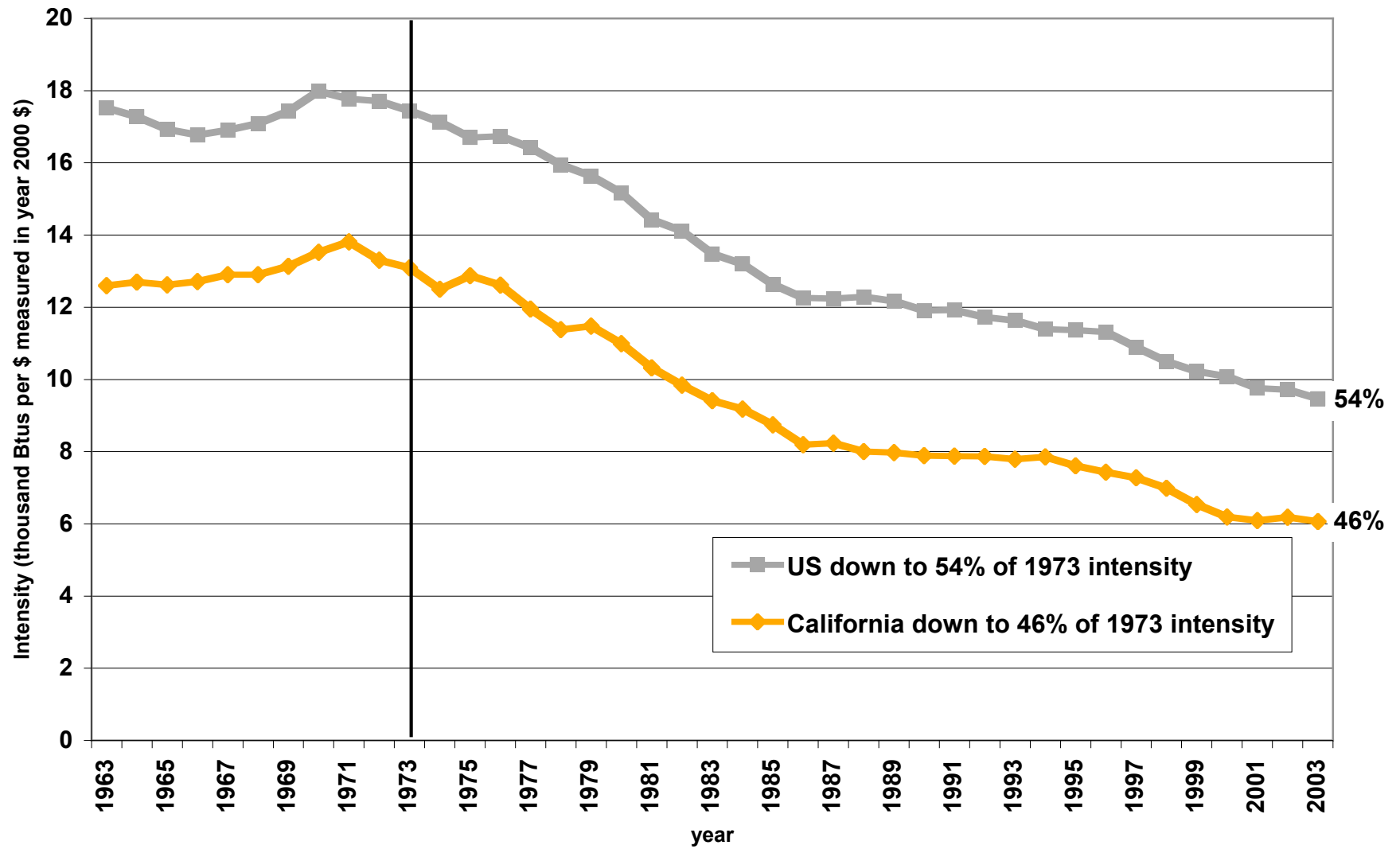
- ◆ Beginning in 2007 in California, reduction of “vampire” or stand-by losses
 - This will save \$10 Billion when finally implemented, nation-wide
- ◆ Out of a total **\$700 Billion**, a crude summary is that 1/3 is structural, 1/3 is from transportation, and 1/3 from buildings and industry.

A supporting analysis on the topic of efficiency from Vice-President Dick Cheney

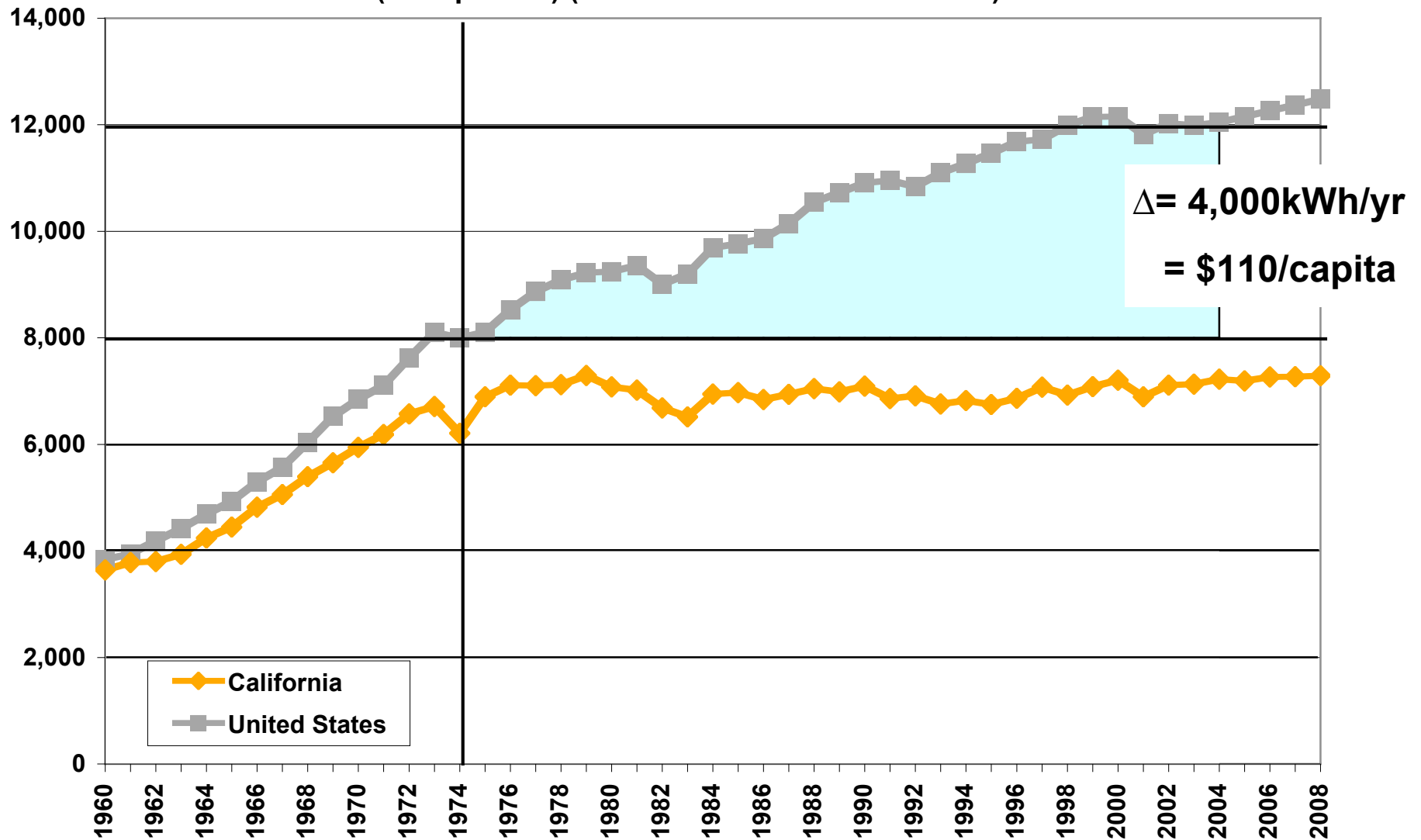
- ◆ “Had energy use kept pace with economic growth, the nation would have consumed 171 quadrillion British thermal units (Btus) last year instead of 99 quadrillion Btus”
- ◆ “About a third to a half of these savings resulted from shifts in the economy. The other half to two-thirds resulted from greater energy efficiency”

Source: National Energy Policy: Report of the National Energy Policy Development Group, Dick Cheney, et. al., page 1-4, May 2001

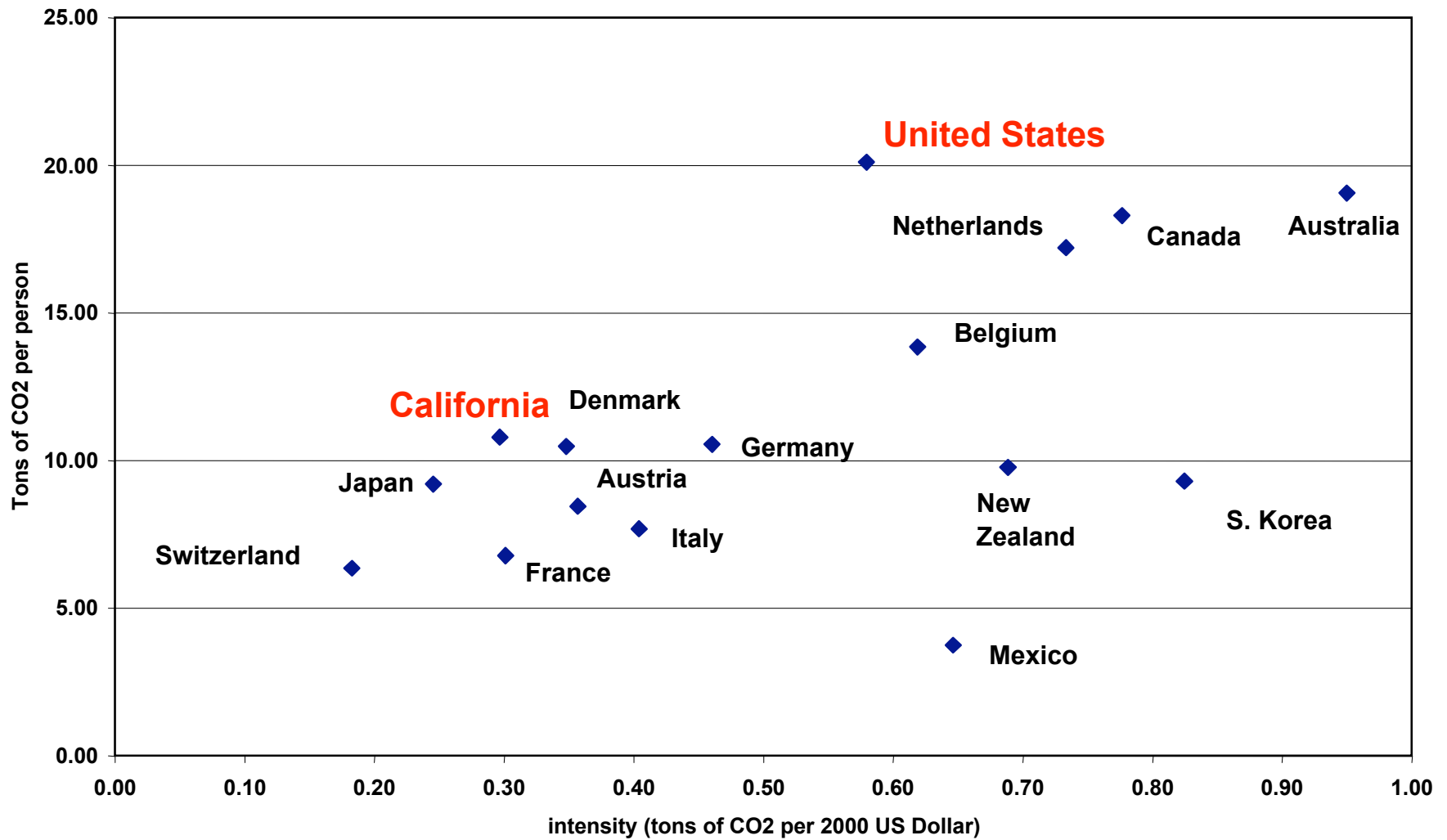
Energy Intensity -- California and the United States



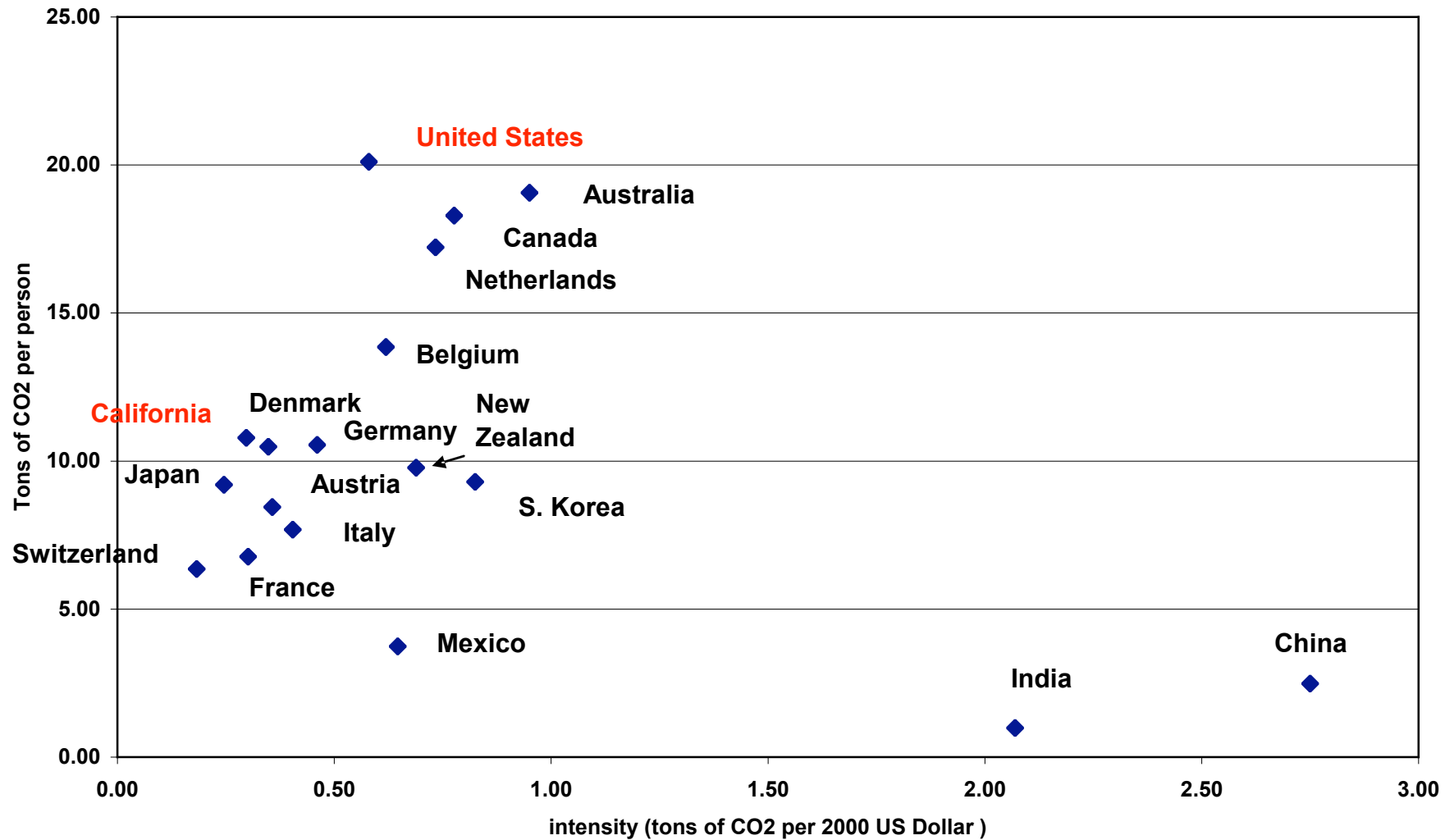
Per Capita Electricity Sales (not including self-generation)
(kWh/person) (2005 to 2008 are forecast data)



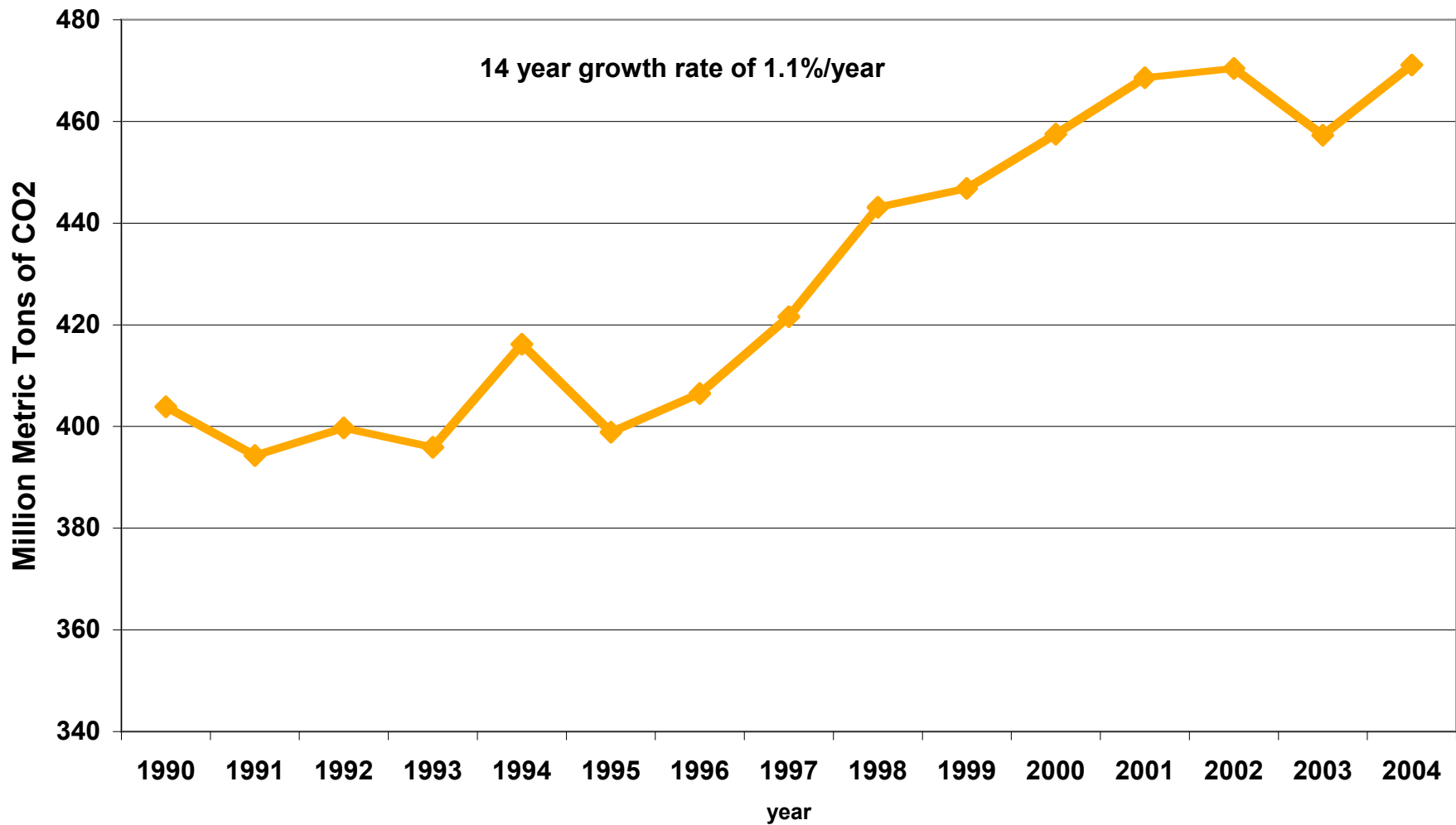
Carbon Dioxide Intensity and Per Capita CO2 Emissions -- 2001
(Fossil Fuel Combustion Only)



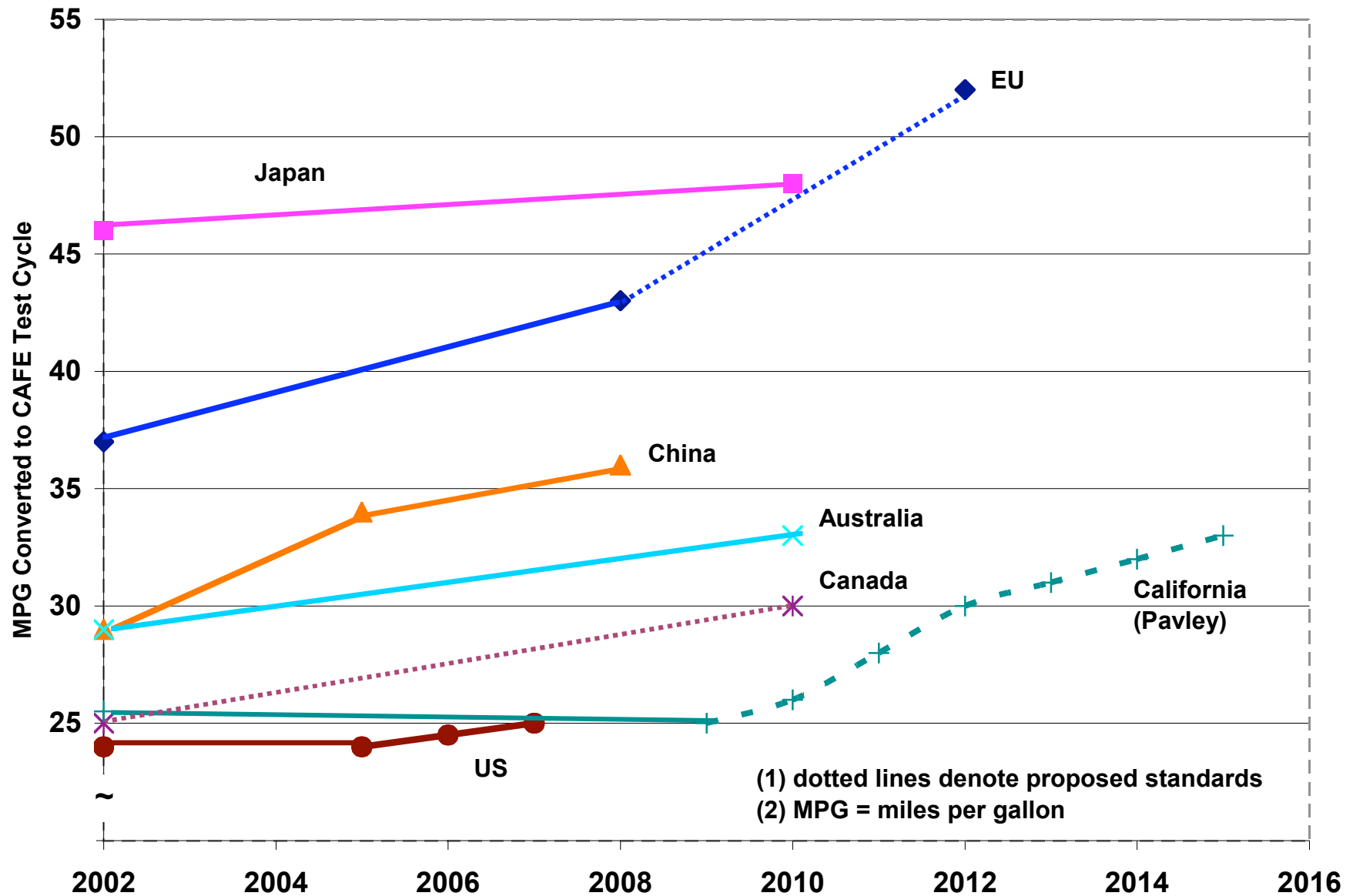
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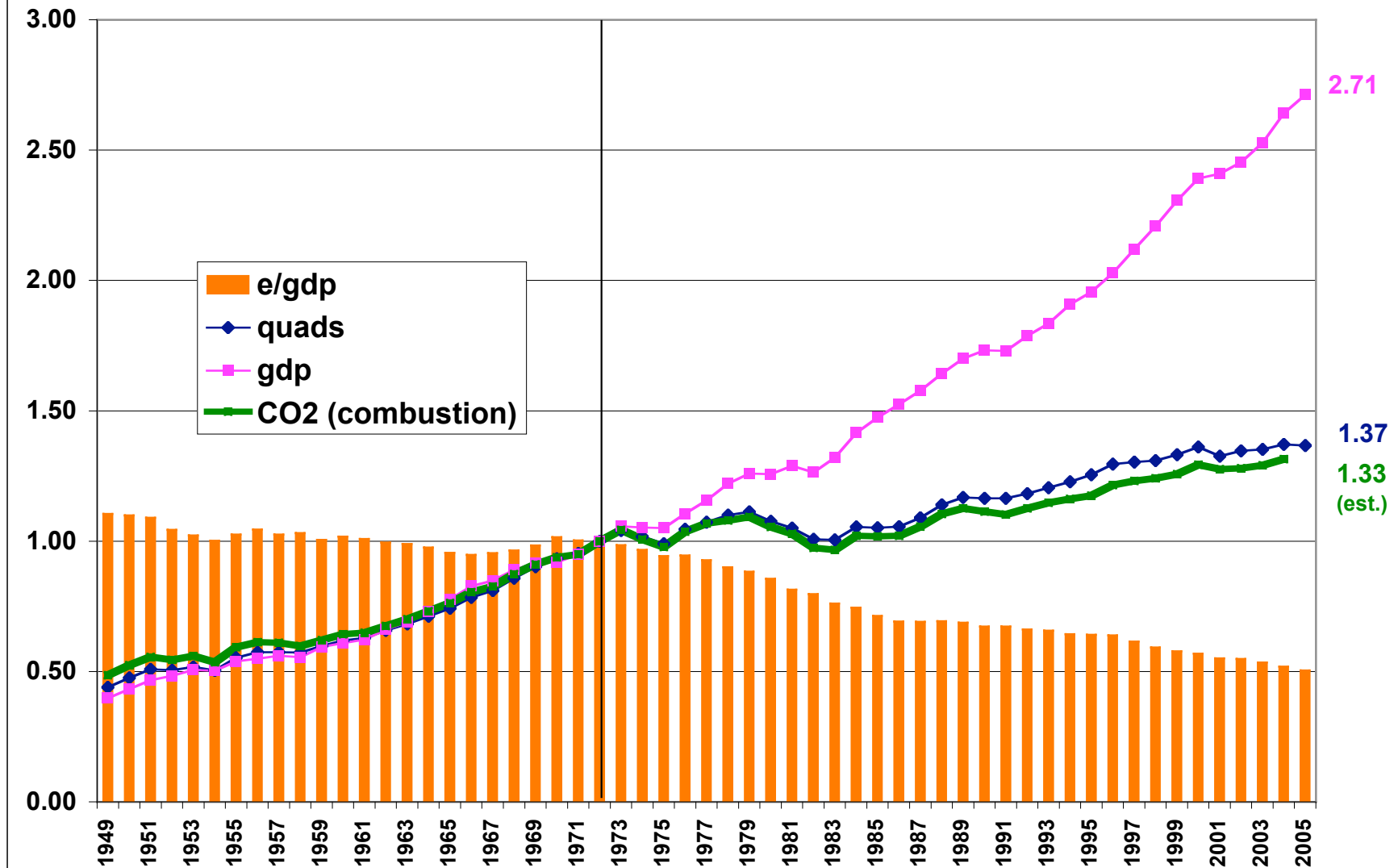
CO2 Emissions in California Including Electricity Imports 1990 - 2004



Comparison of Fuel Economy – Passenger Vehicles

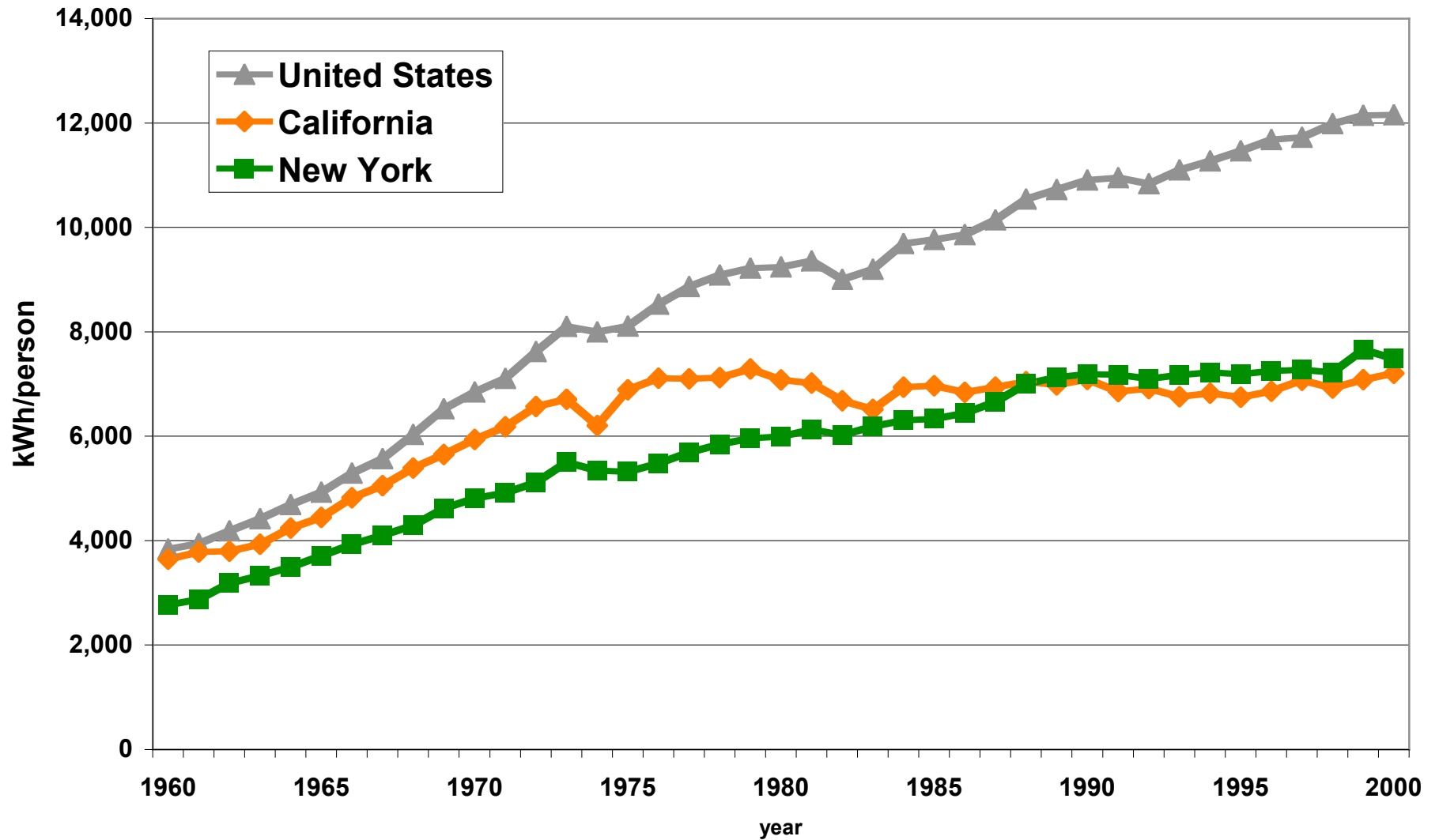


Index (1972 = 1.00) of U.S. Energy Use, GDP, Energy Intensity and Carbon Dioxide
last 10-year CO2 growth = 1.3% per year

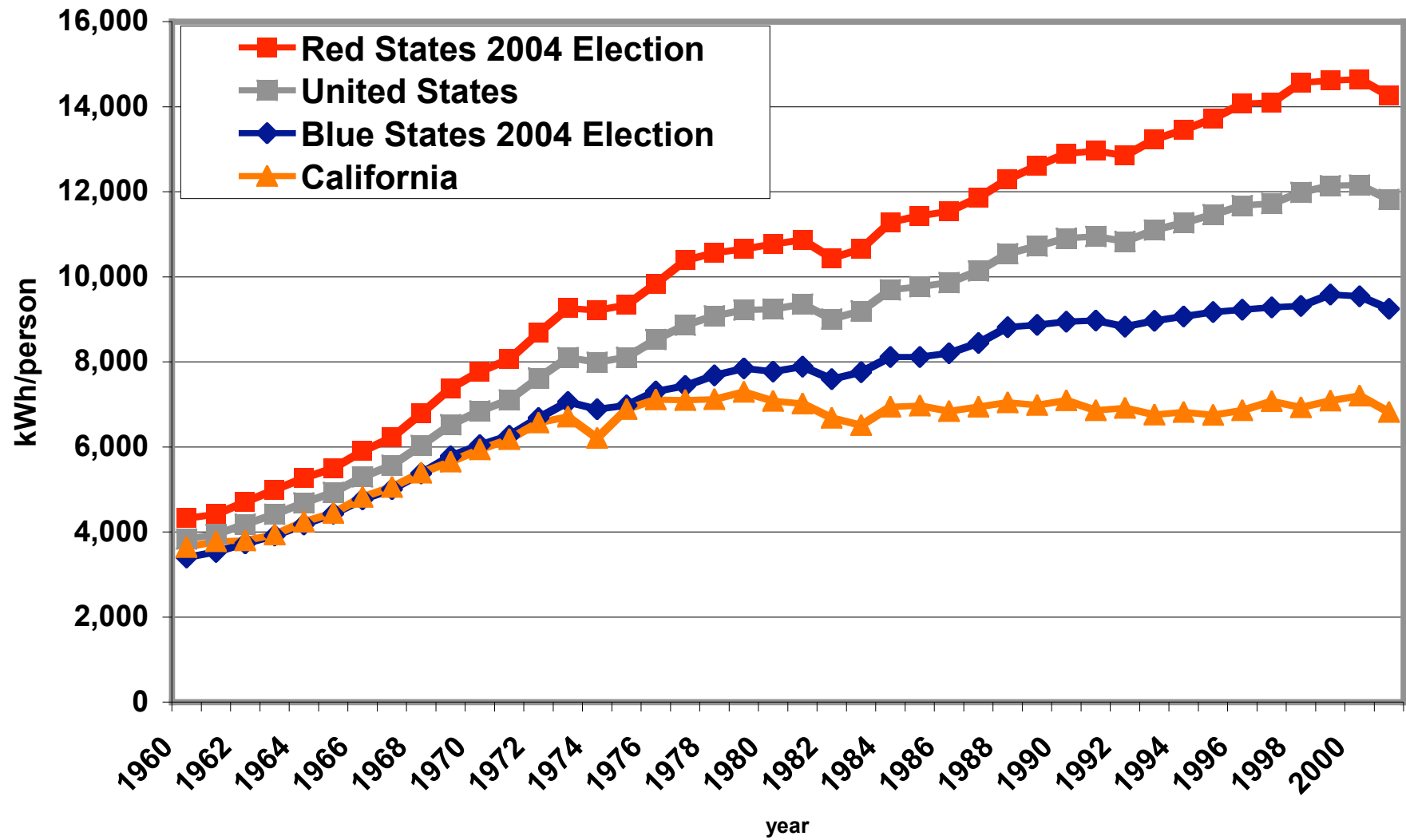


Per Capita Electricity Consumption

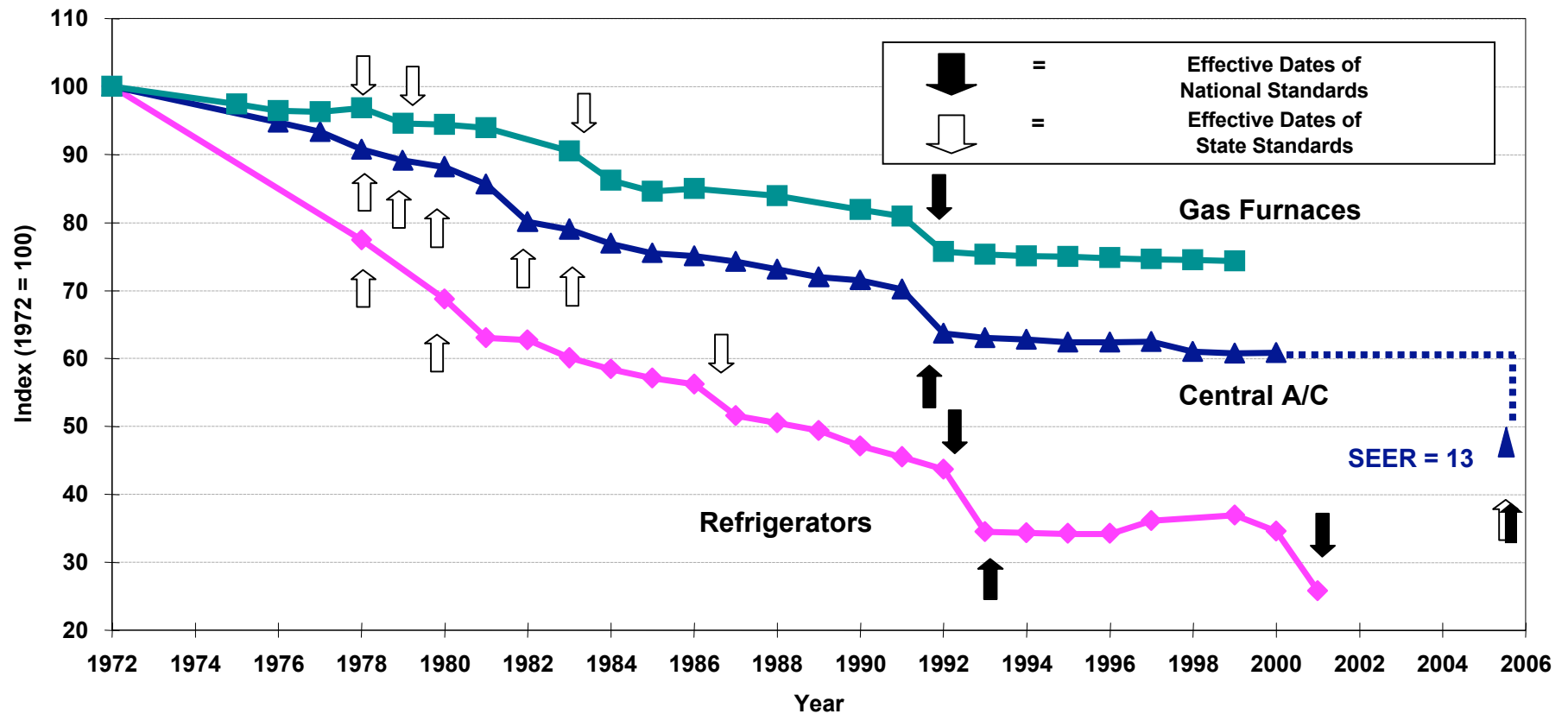
Source: http://www.eia.doe.gov/emeu/states/sep_use/total/csv/use_csv



Per Capita Electricity Consumption



Impact of Standards on Efficiency of 3 Appliances

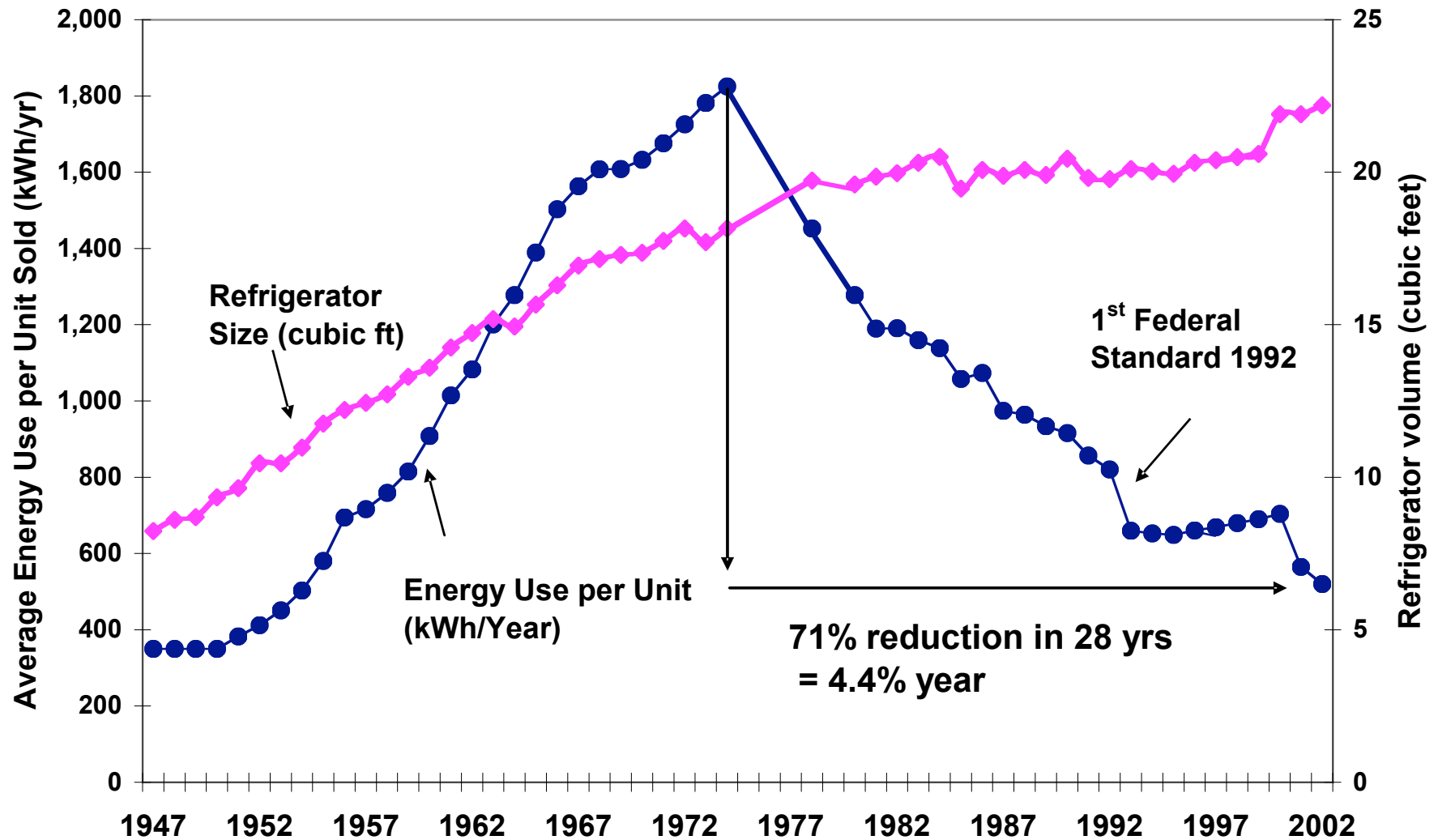


Source: S. Nadel, ACEEE,
in ECEEE 2003 Summer Study, www.eceee.org

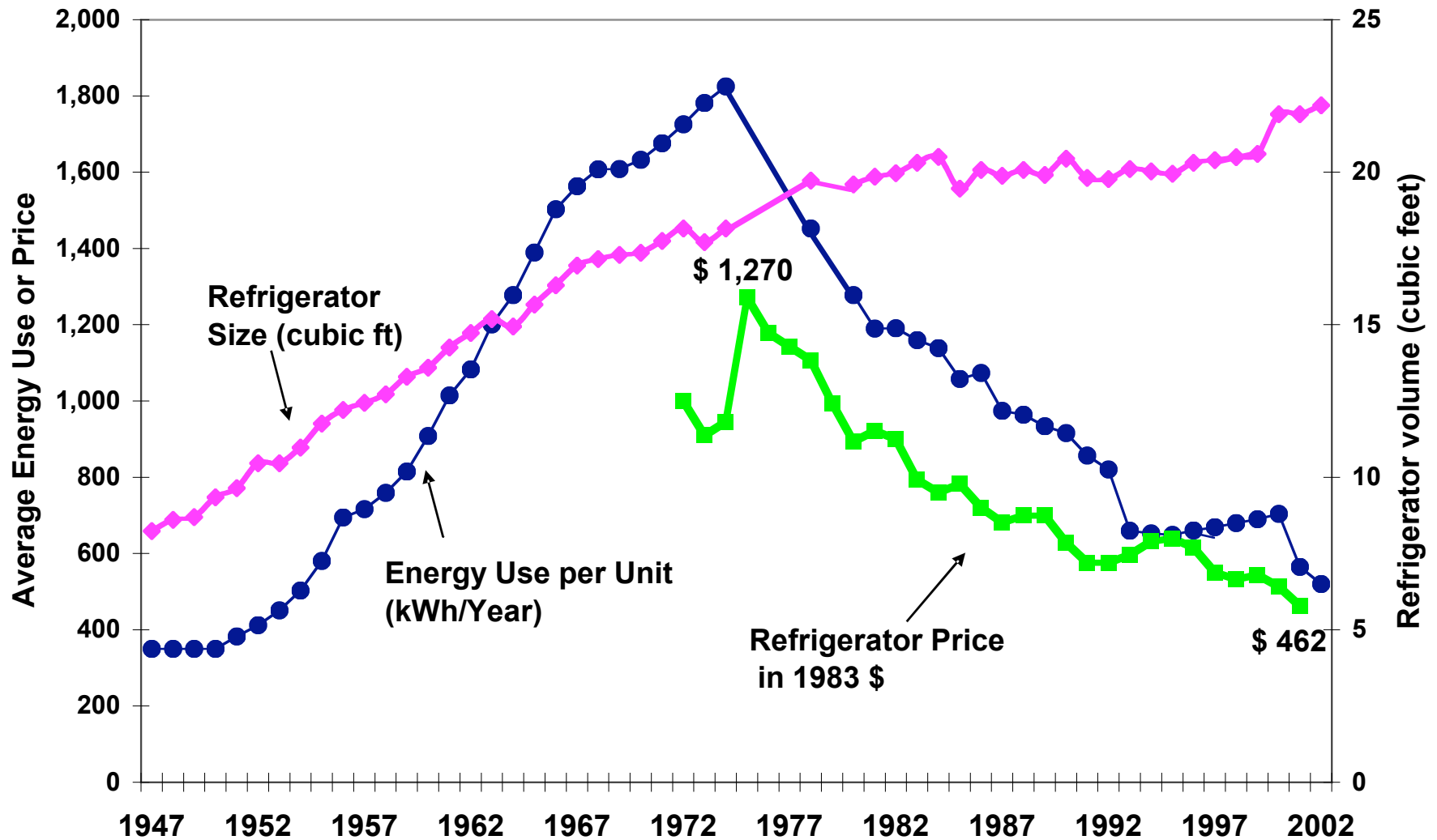
Impact on Lighting of Building + Appliance Standards

- ◆ **United States Best Practice measured in Watts/Sq. Ft. of Commercial Building floor area.**
- ◆ **In 1974 = 4 Watts/Sq. Ft.**
- ◆ **In 2006 = 0.8 Watts/Sq. Ft.**
- ◆ **An Enlightened reduction to 1/5**
- ◆ **Drivers: Standards, electronic ballasts, and currently, “scotopic” (blue-ish) color, all thanks to LBNL and Sam Berman.**

New United States Refrigerator Use v. Time

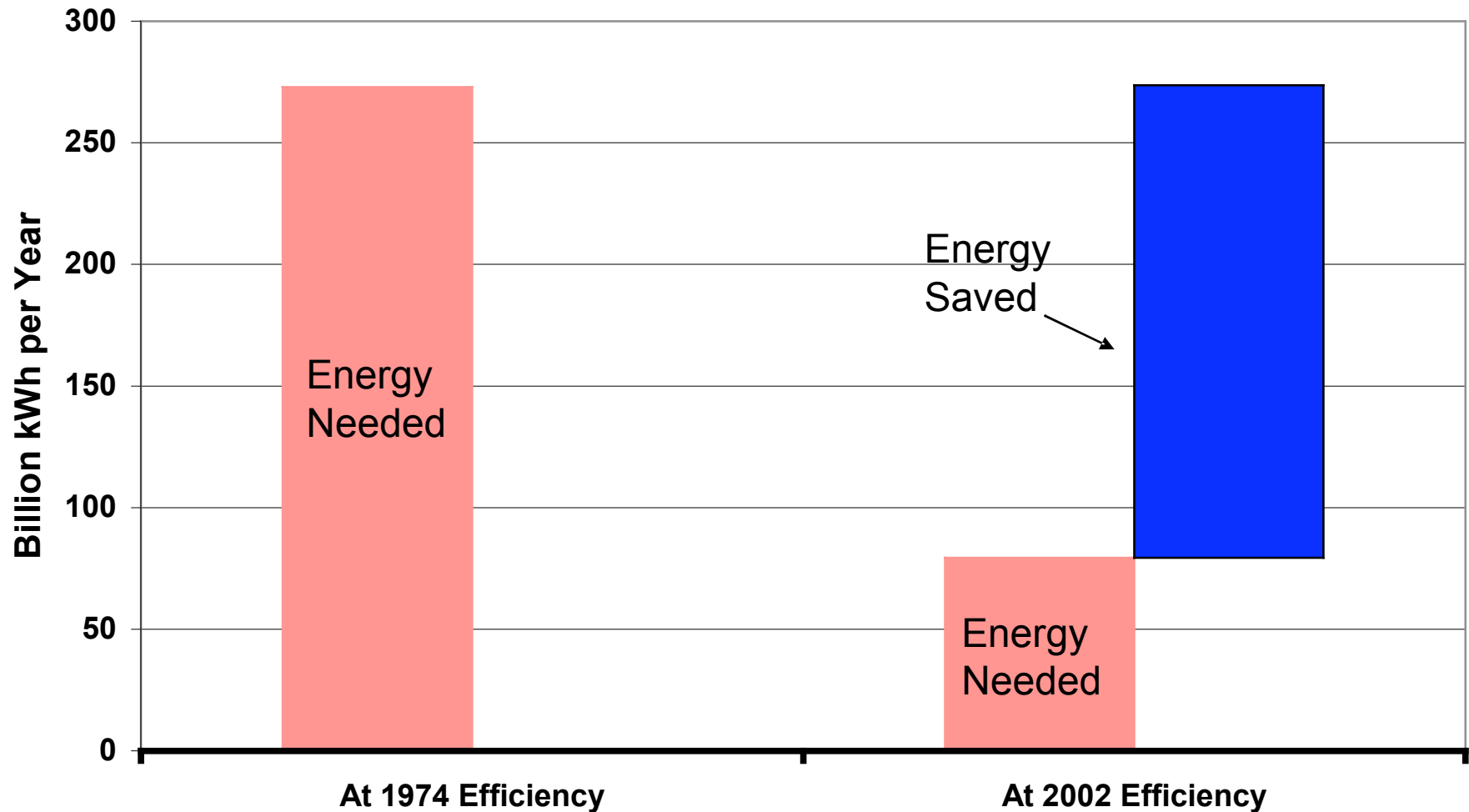


New United States Refrigerator Use v. Time and Retail Prices

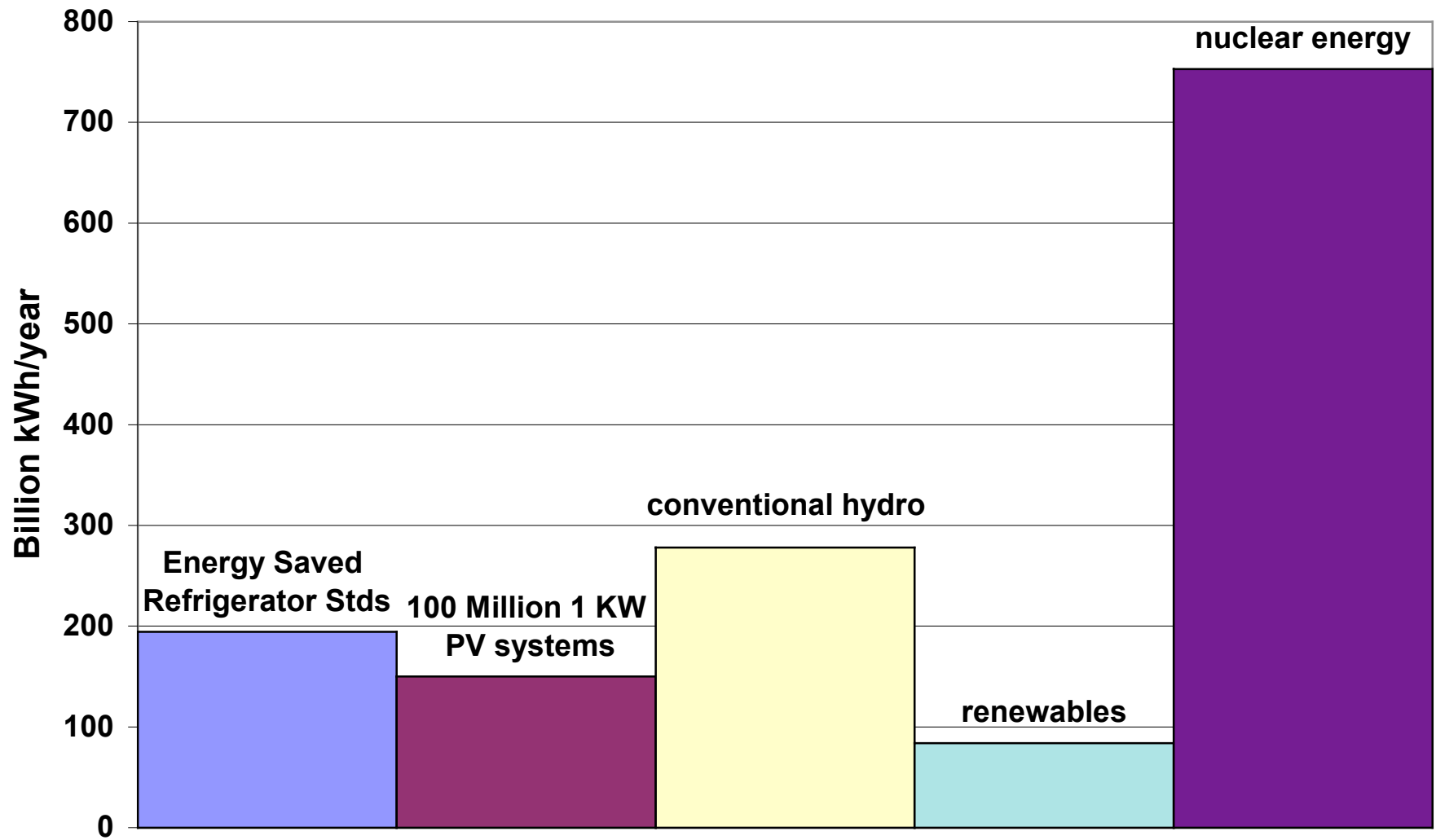


Source: David Goldstein

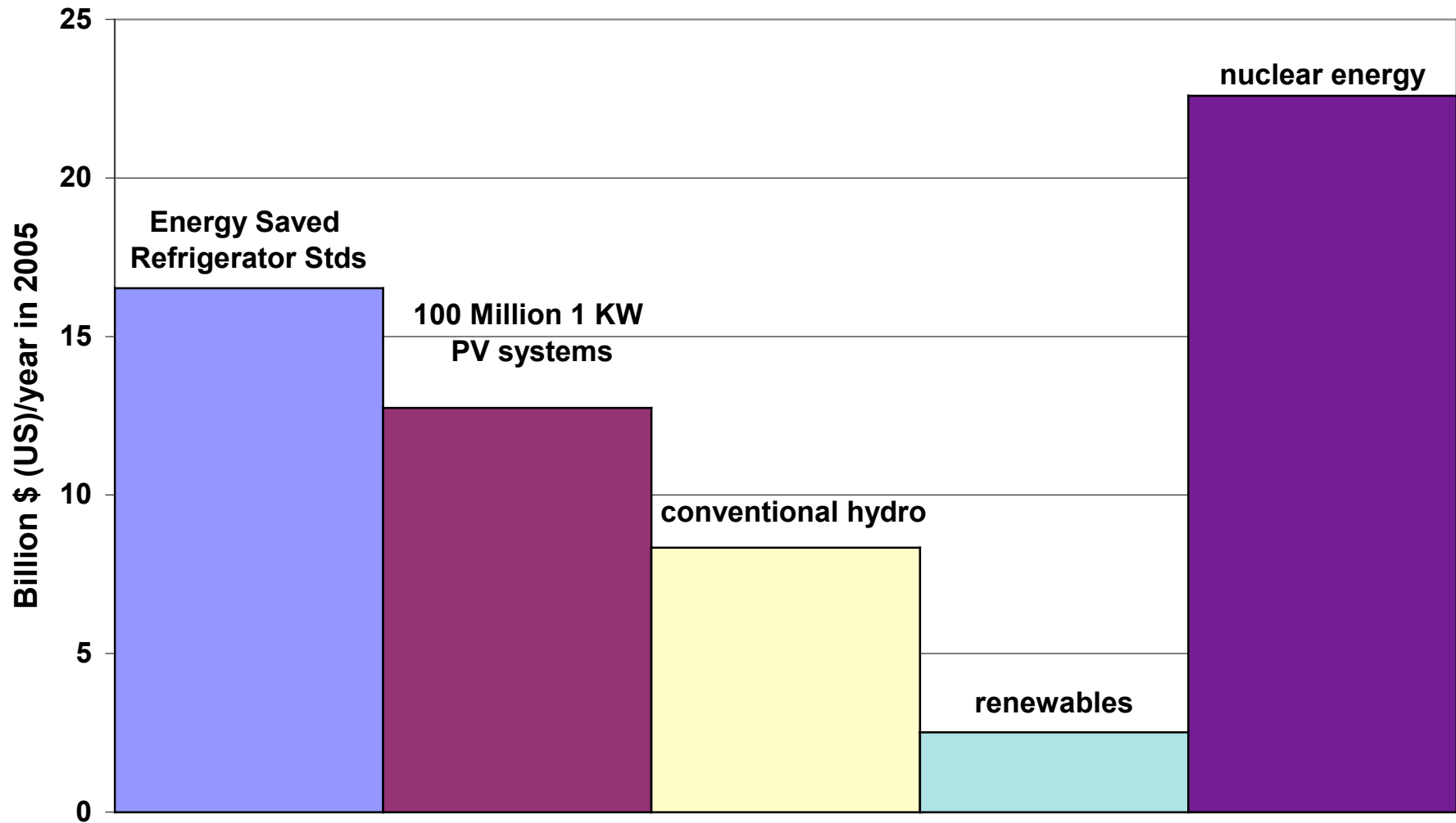
New Refrigerator Energy Use: 71% will be saved when stock completely turns over to 2001 Standards



Annual Energy Saved vs. Several Sources of Supply

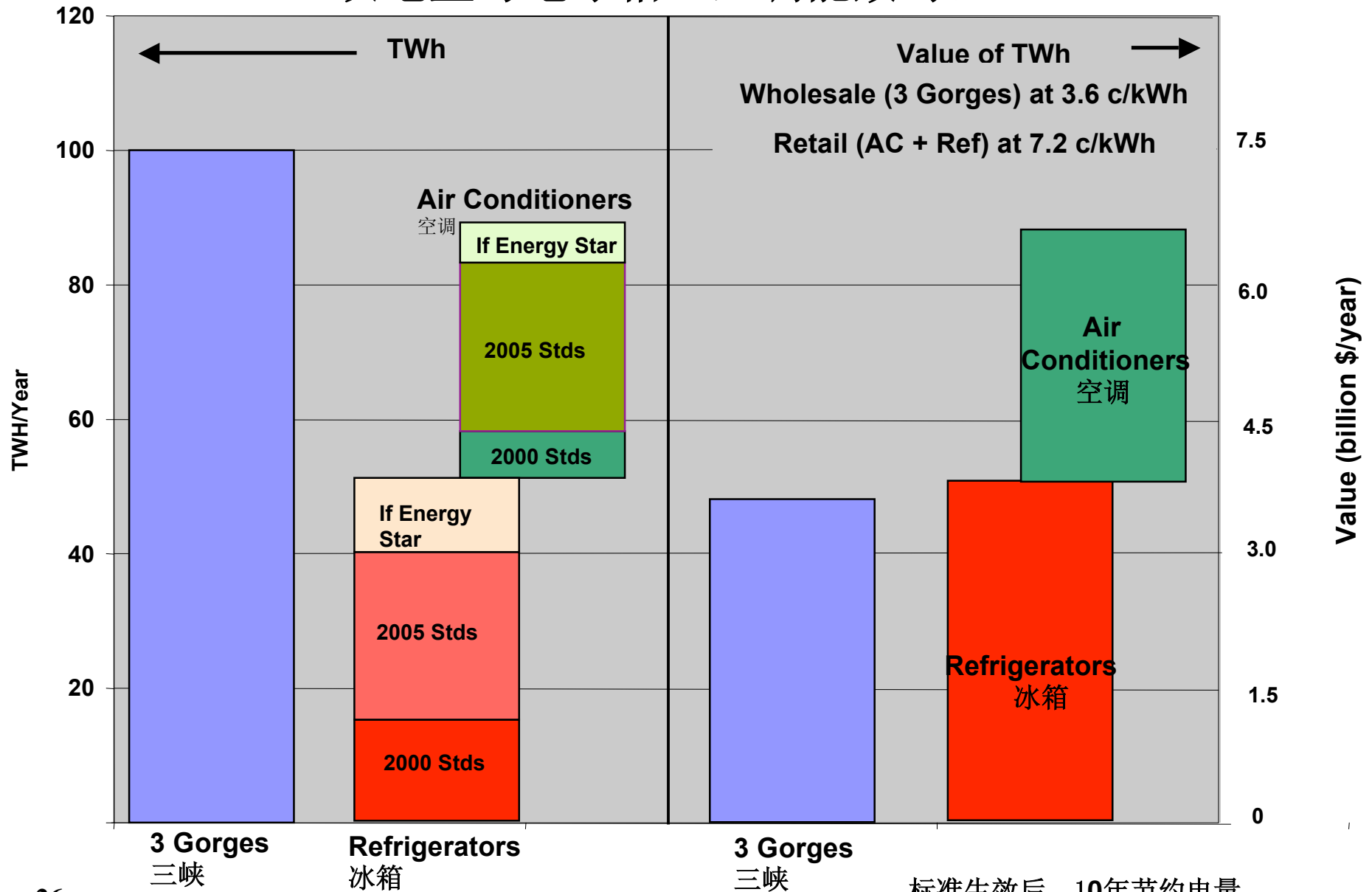


**Value of Energy to be Saved (at 8.5 cents/kWh, retail price) vs.
Several Sources of Supply in 2005 (at 3 cents/kWh, wholesale price)**



Comparison of 3 Gorges to Refrigerator and AC Efficiency Improvements

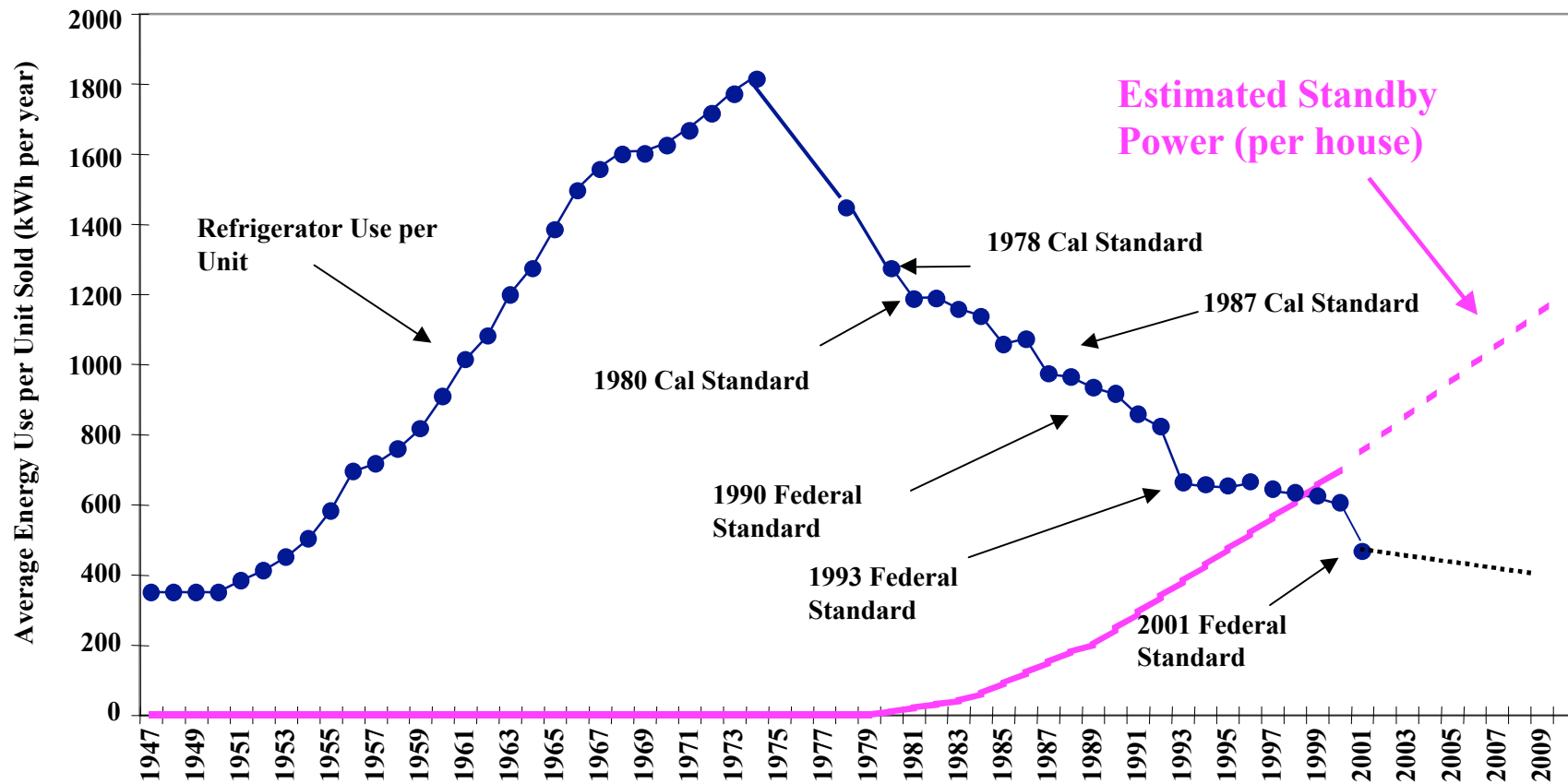
三峡电量与电冰箱、空调能效对比



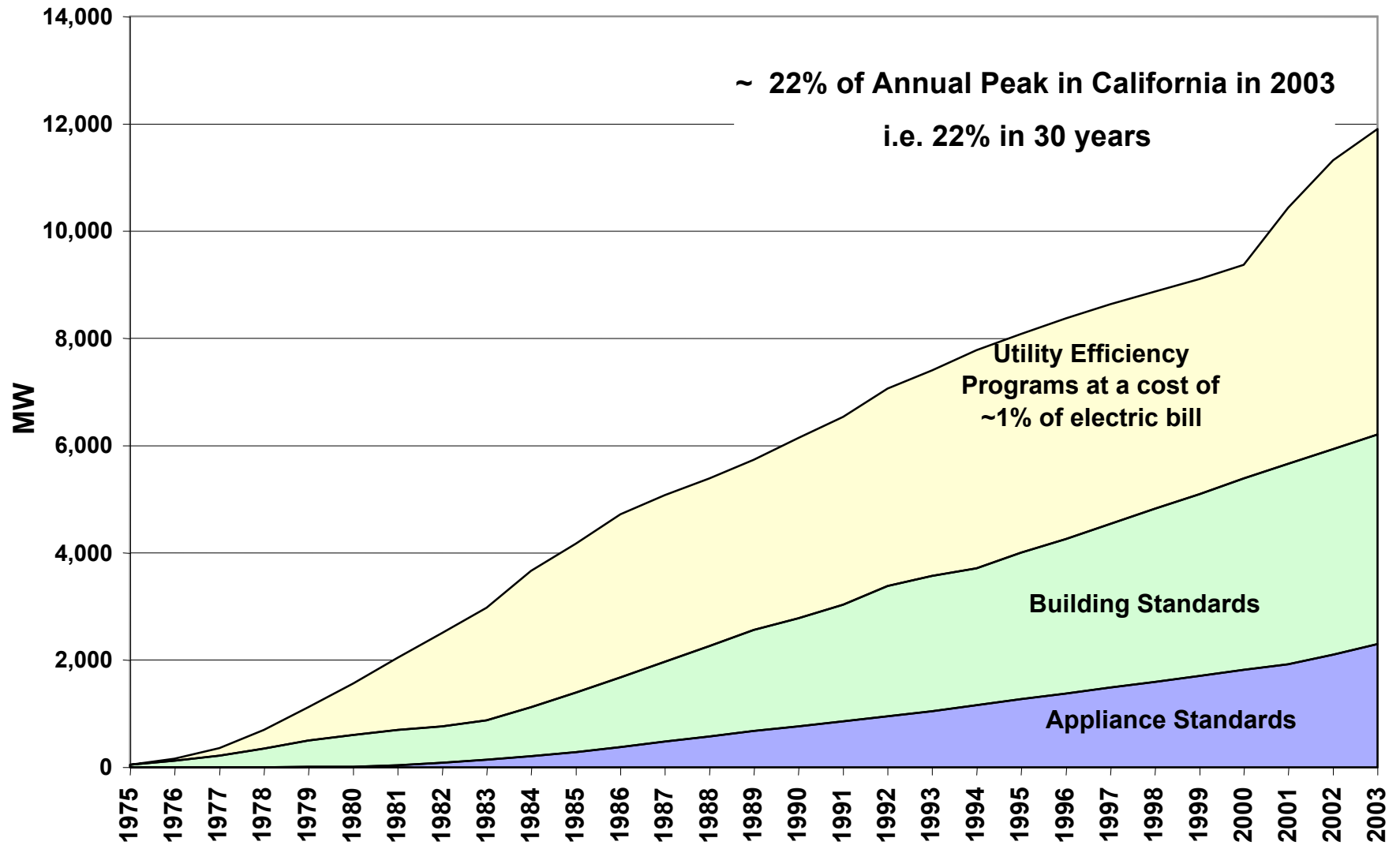
Savings calculated 10 years after standard takes effect. Calculations provided by David Fridley, LBNL

标准生效后，10年节约电量

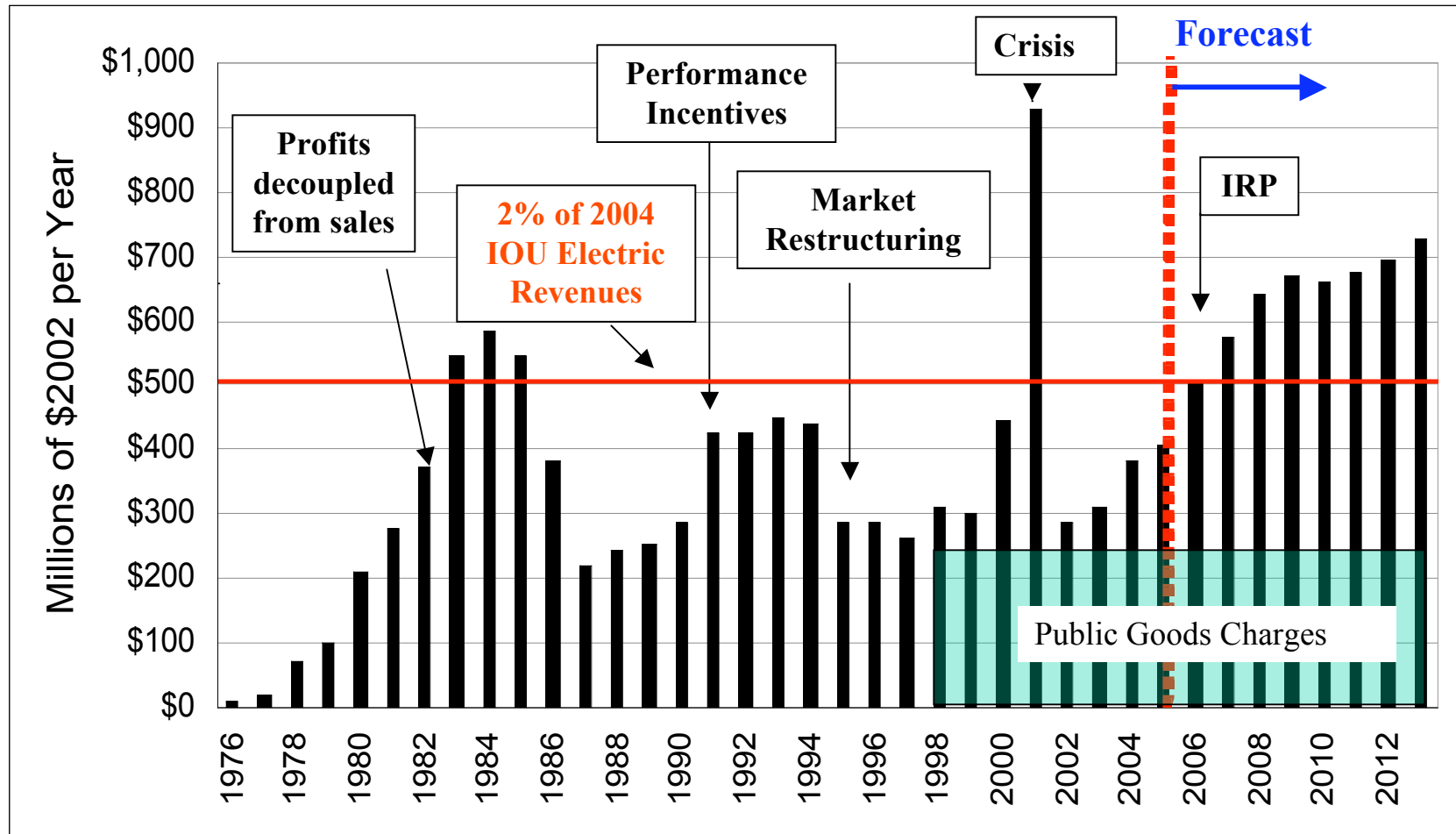
United States Refrigerator Use, repeated, to compare with Estimated Household Standby Use v. Time



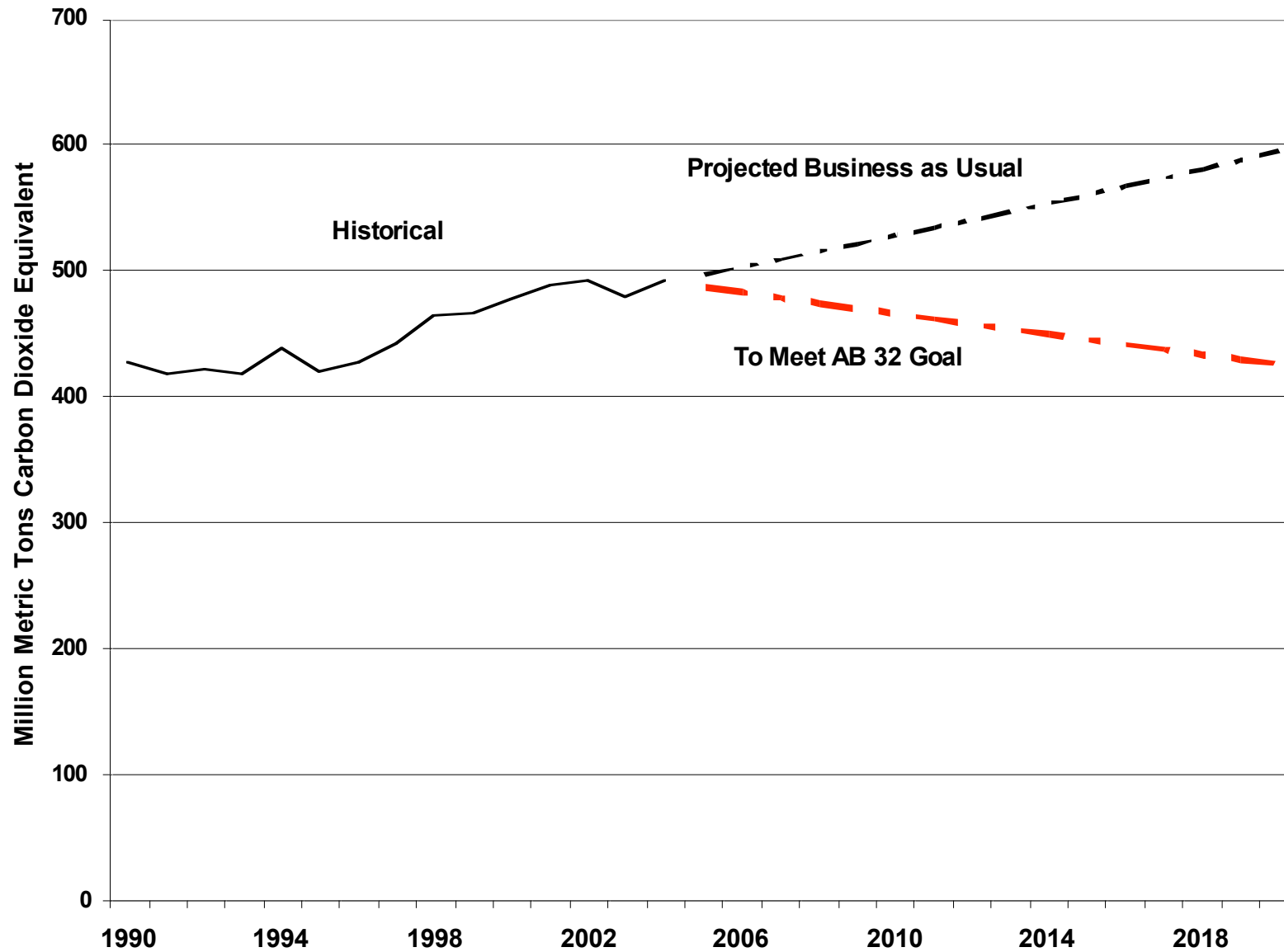
Annual Peak Savings from Efficiency Programs and Standards



California IOU's Investment in Energy Efficiency

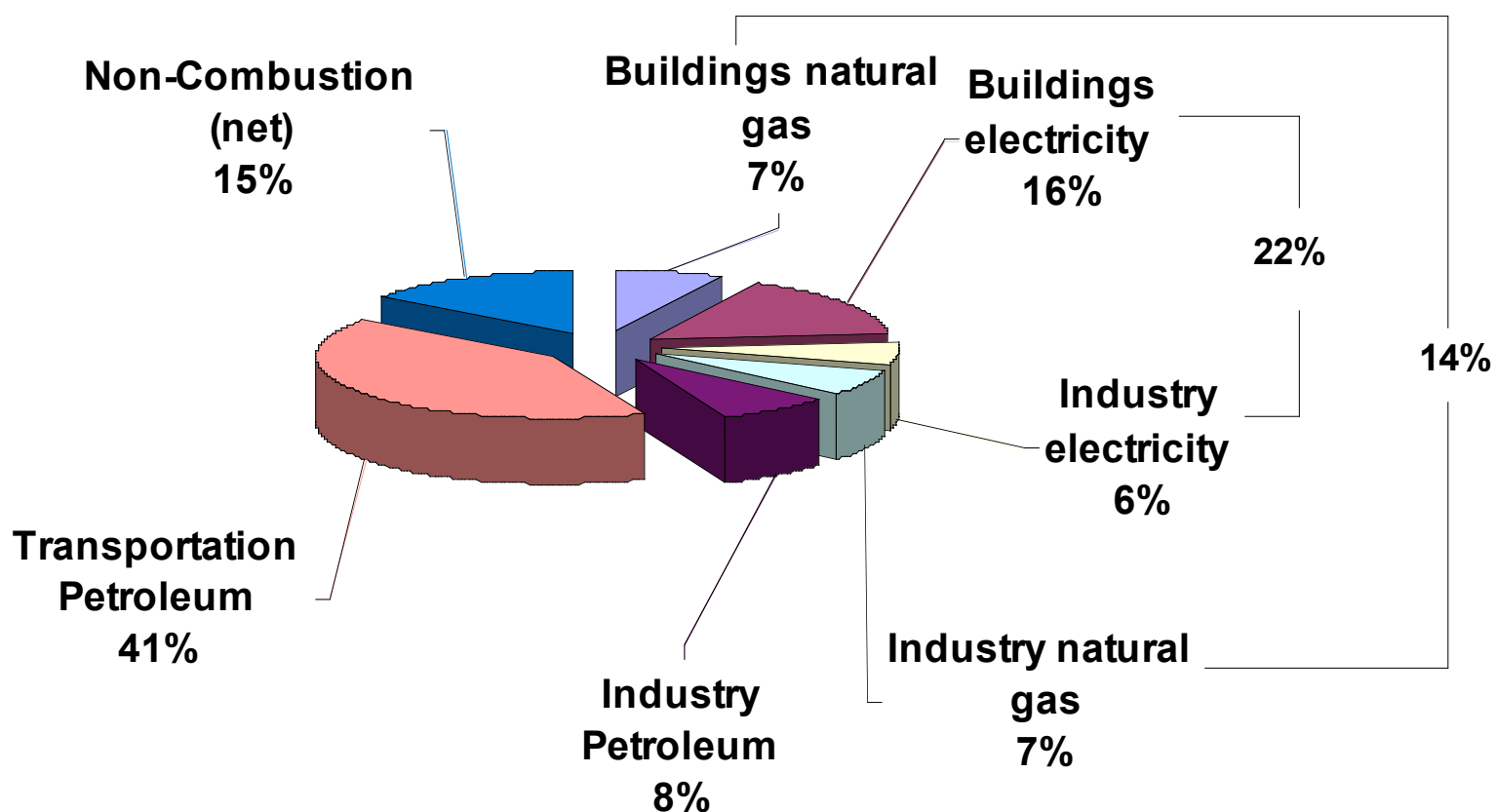


CO2 Emissions in California: Historical and Projected



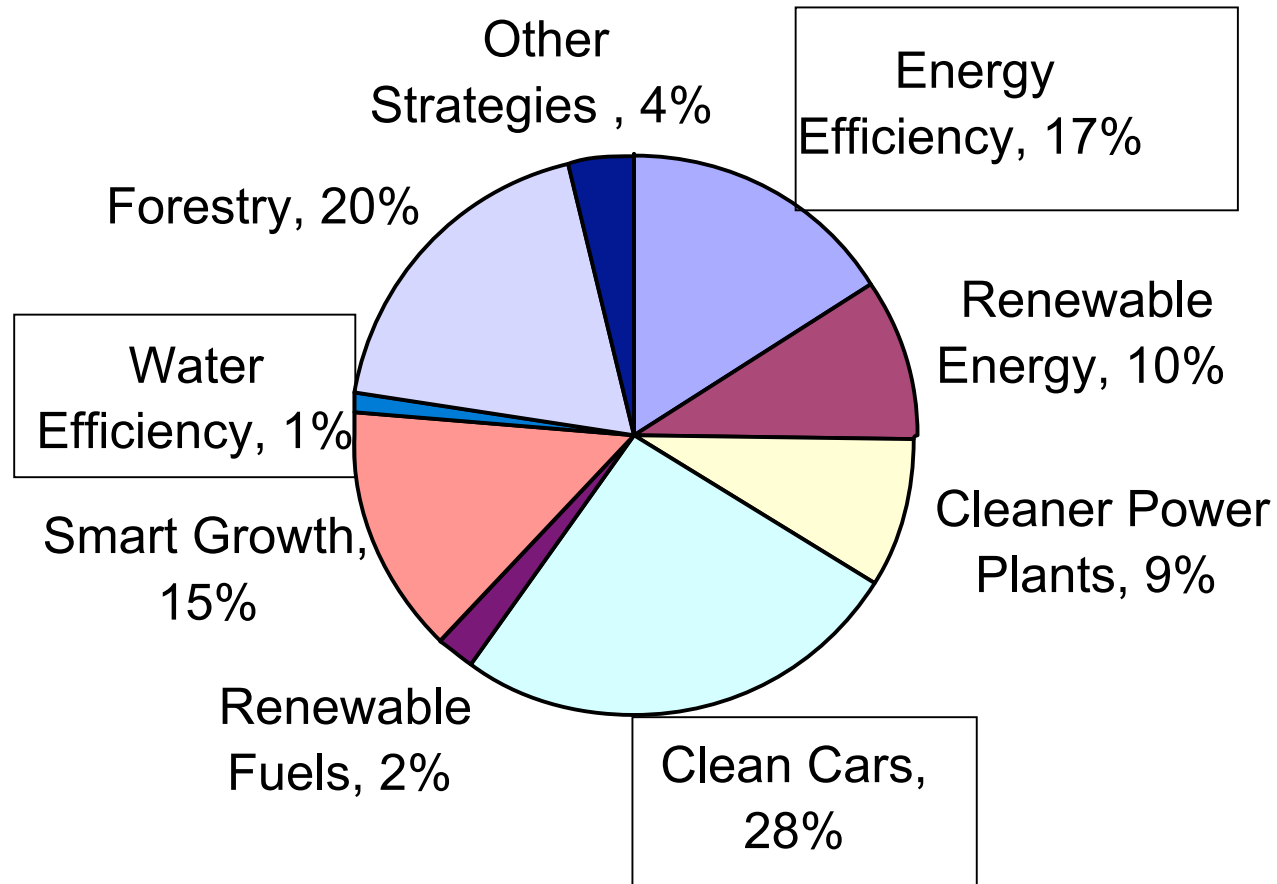
Emissions of CO2 in California by End Use in 2004

Total Emissions = 490 Million metric tons CO2 equivalent



Strategies for Meeting California's CO2 Goals in 2020

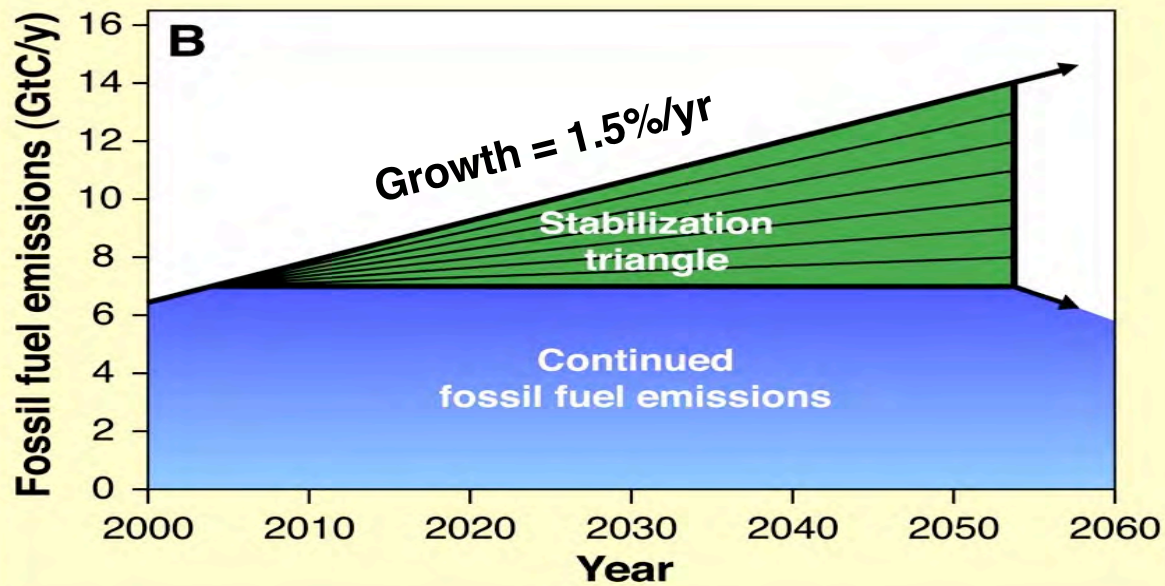
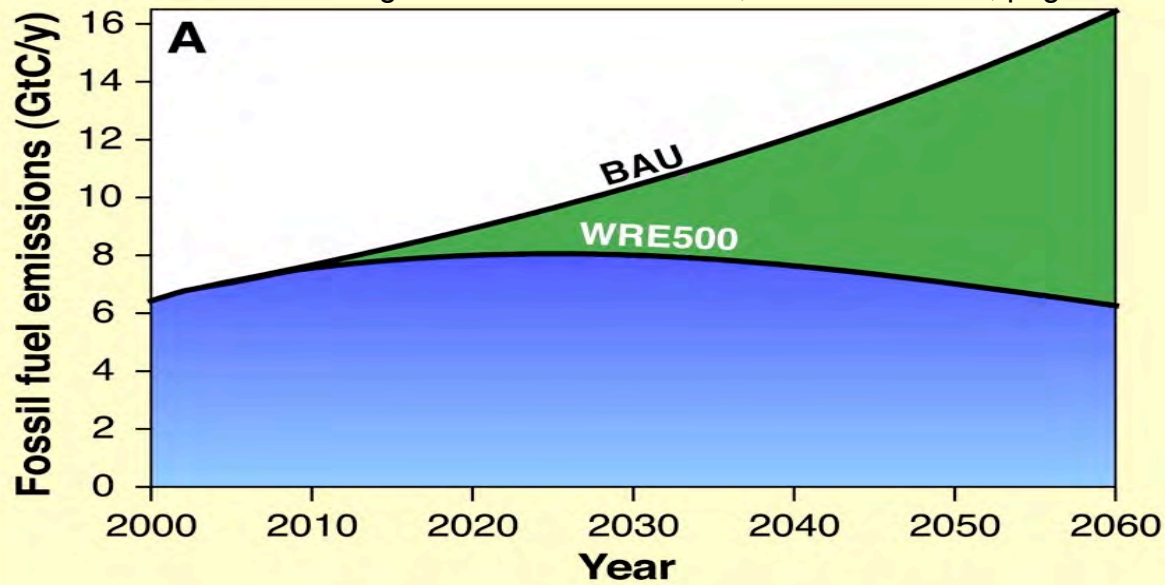
Total Reductions = 174 Million metric Tons CO2 equivalent



Initiatives in Efficiency

- ◆ “Fleet” Average for Lighting Efficiency to reduce incandescent share
 - Measured in lumens/watt
- ◆ Air conditioning standards
 - U.S. split into regions based on type of weather
 - Hot/dry west differs from warm/wet southeast
 - With peak load as the focus, not seasonal efficiency— “SEER”
- ◆ White roofs on existing buildings
- ◆ Benchmarking of Commercial Buildings
 - Fine tuning of energy management systems

Source: Stabilization Wedges: Pacala and Socolow, Science Vol 305, page 968



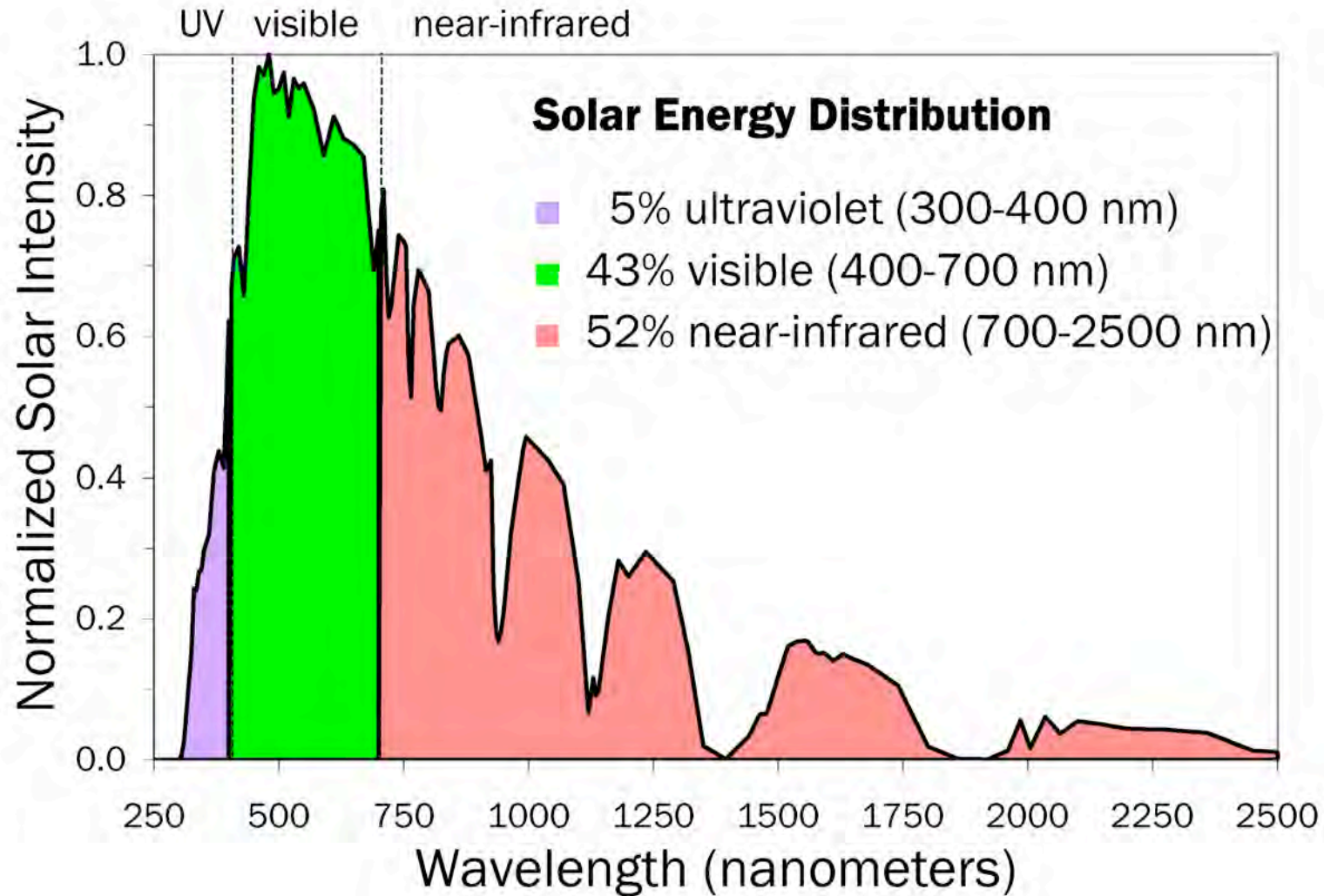
Illuminating Space vs. the Street



Heat Mirror Windows – Steve Selkowitz, LBNL

- ◆ Low Emissivity films are required by building standards world-wide. They reflect far infrared radiation. Retain indoor heat in winter, reflect outdoor heat in summer. They double the R-value of double glazing, and the inside pane is warm to the touch – more comfortable
- ◆ Before low-E, windows were 30% of the heat load of a home – now 15%.
- ◆ During a Montana winter, a north-facing low-E window, facing a snowy sunlit slope, is a net energy gainer.
- ◆ “Selective film are required for Commercial Buildings in California. They reflect far- and near-infrared radiation, and halve the solar gain through windows; including car windshields in BMW’s etc.
- ◆ **Modern windows save ~1 Mbod of oil equivalent, = Alaskan oil.**

Cool Colors Reflect Invisible Near-Infrared Sunlight





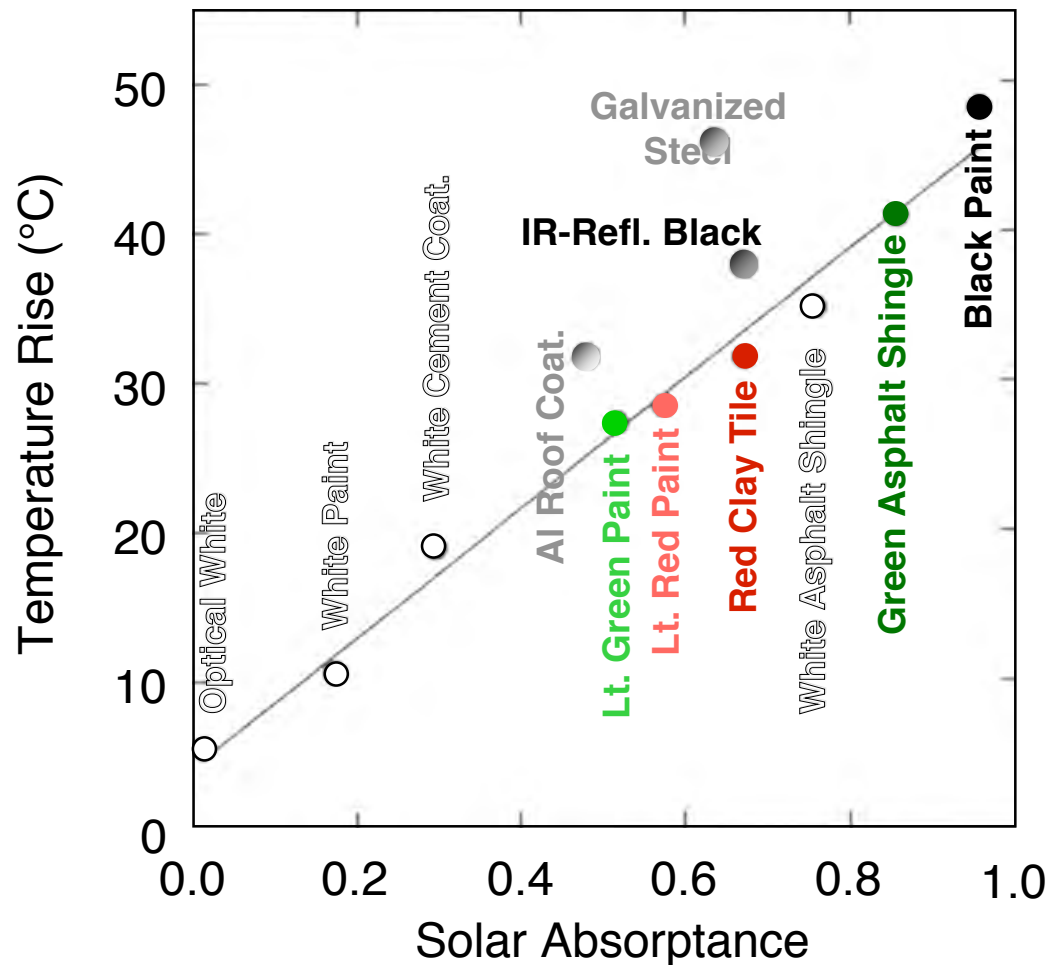
http://www.nwhi.net/Vinyl_Windows/Low_E_Glass.htm



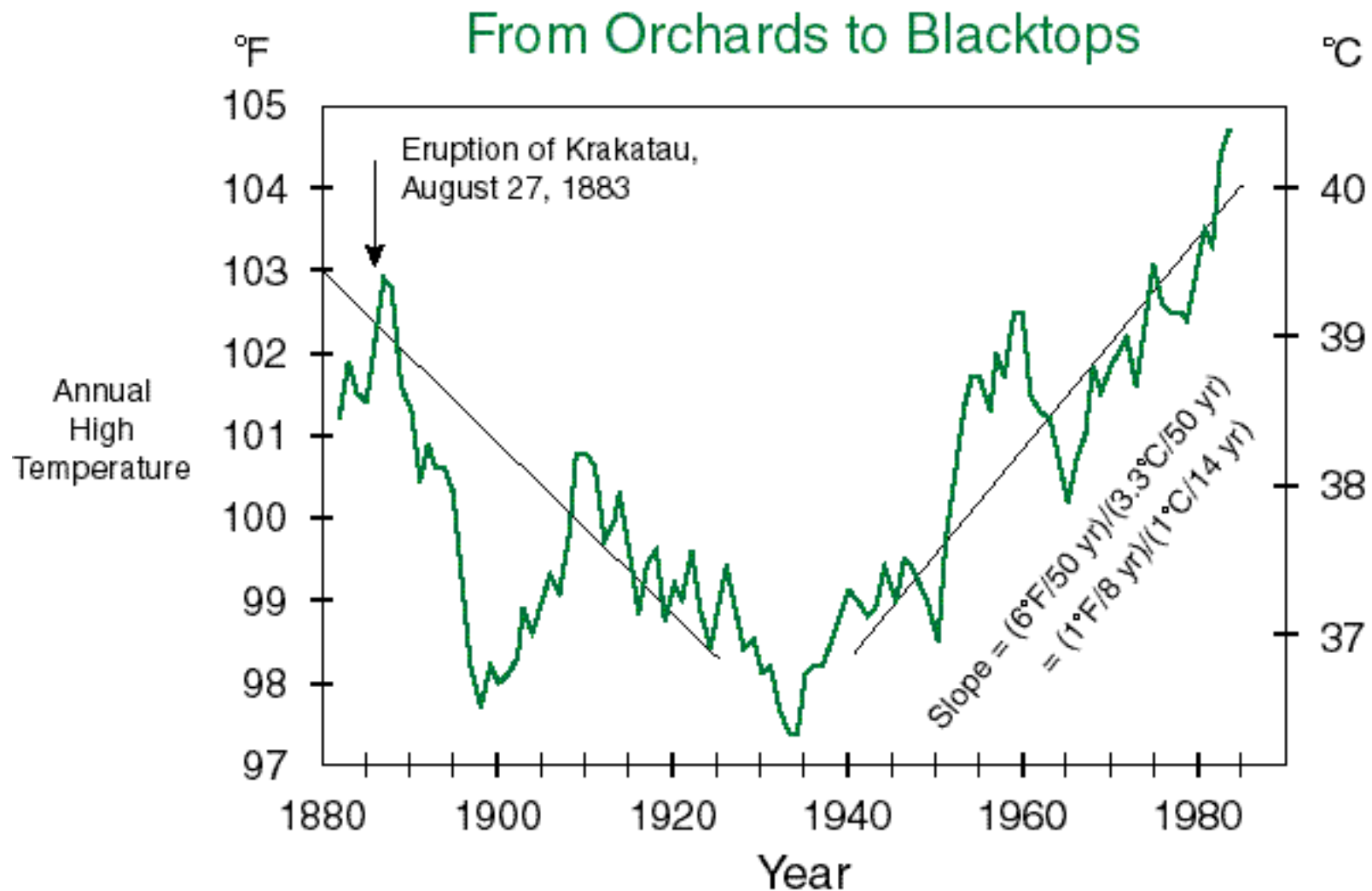
http://www.nwhi.net/Vinyl_Windows/Low_E_Glass.htm

Temperature Rise of Various Materials in Sunlight

Dr. Hashem Akbari, LBNL Heat Island Group

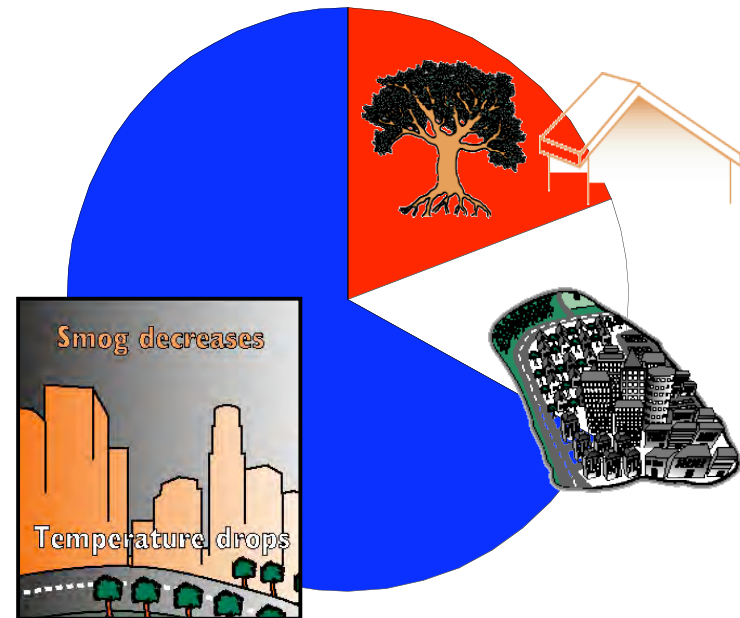


Temperature Trends in Downtown Los Angeles

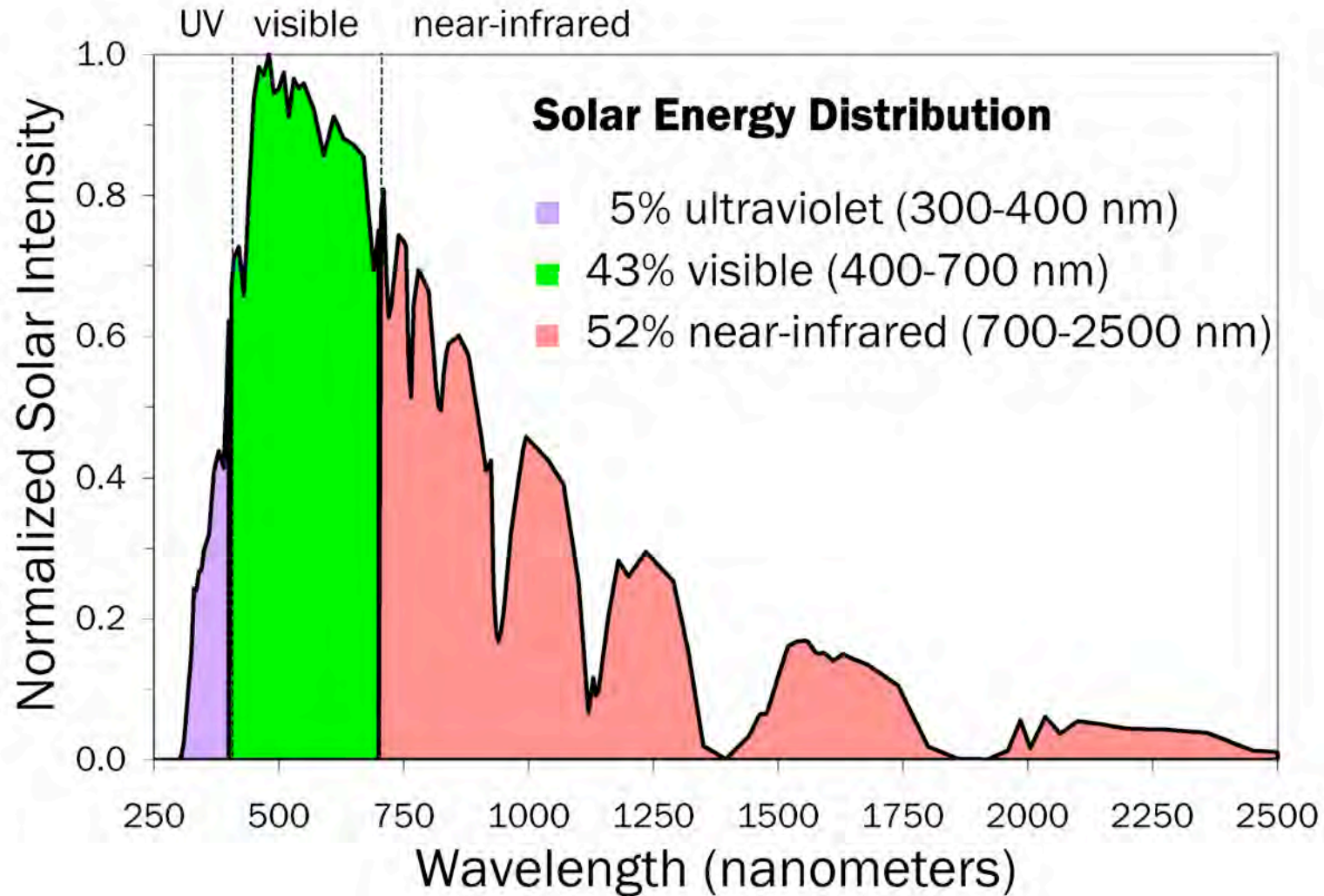


Potential Savings in LA

- ◆ **Savings for Los Angeles**
 - Direct, \$200M/year
 - Indirect, \$140M/year
 - Smog, \$360M/year
- ◆ **Estimate of national potential savings: \$5B/year**



Cool Colors Reflect Invisible Near-Infrared Sunlight

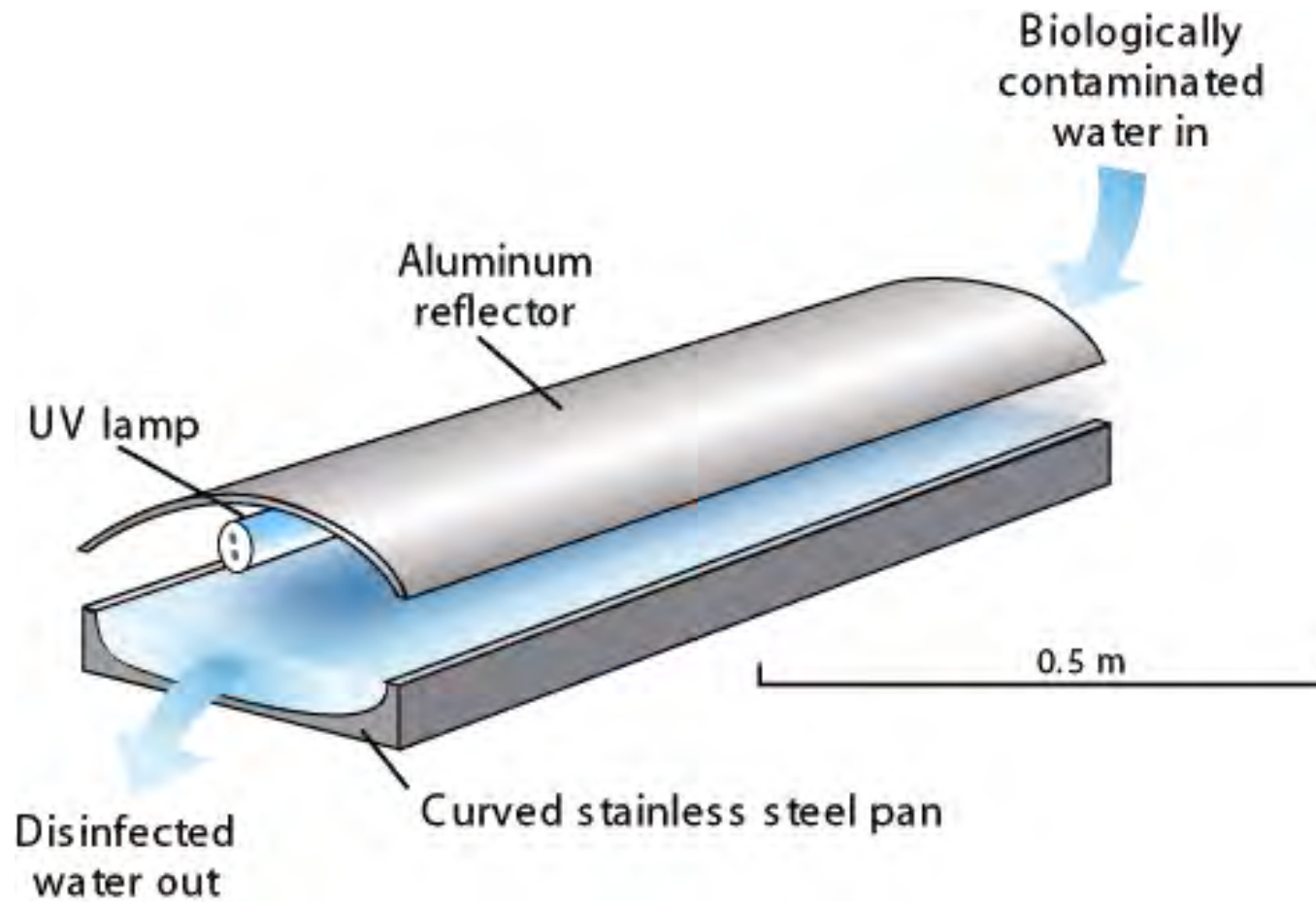


From Cool Color Roofs to Cool Color Cars



- ◆ Toyota experiment (surface temperature 10K cooler)
- ◆ Ford and Fiat are also working on the technology

UV Water Purification



Kothapeta (Dec. 2005) commissioning test





Typical interior layout of
the WaterHealth
Community System
Installation
in Kothapeta

**Source: Dr. Ashok Gadgil,
LBNL**

Ultra Violet Water Purification for Villages in Developing World

Ashok Gadgil at LBNL points out if UV treatment replaces boiling 10 tons of water per day, each system avoids 3 tons of CO₂ per day. An American car emits only 4 tons of CO₂ per YEAR. Cost of an avoided ton of CO₂ is \$0.35, vs. EU price of \$20.

- ◆ Meet / exceed WHO and US EPA criteria
- ◆ Energy efficient: 60 watts disinfects 1 ton / hour
- ◆ Low cost: 4 cents disinfects a ton of water
- ◆ Reliable, Mature components
- ◆ Can treat un-pressurized water
- ◆ Rapid throughput: 12 seconds under lamp
- ◆ Low maintenance: once every three months
- ◆ >50 units now operating in India and Philippines
- ◆ <http://www.waterhealth.com/>

Dr. Ashok Gadgil's Darfur Cookstove Project

In Nov.-Dec. 2005, he visited Darfur camps, and showed that with a \$10 metal stove, and training to use it, only half the fuelwood is needed.

The stove saves fuelwood worth \$160 annually for a refugee family

Since that time, Ashok Gadgil has improved stove efficiency by another factor of two

<http://www.osti.gov/bridge/servlets/purl/878538-hMpQn3/878538.PDF>



Contact information

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<http://www.ifc.org/led>



LEDs Powered with Photovoltaics

- ◆ Evan Mills at LBNL points out the following:
- ◆ If 1.6 billion people could replace kerosene lamps with LEDs, emissions would drop by the equivalent of 1.3 million barrels of petroleum per day
- ◆ http://eetd.lbl.gov/emills/PUBS/Fuel_Based_Lighting.html
- ◆ The above estimate was for residential lamps only
- ◆ Including commercial uses, Mills estimates > 2 Mbod
- ◆ For comparison, U.S. gasoline use is 9 Mbod

Hurricane lanterns

- ◆ Teachers grading homework with light levels 1% of western standards



Tanzania (teachers' home)

Productive uses



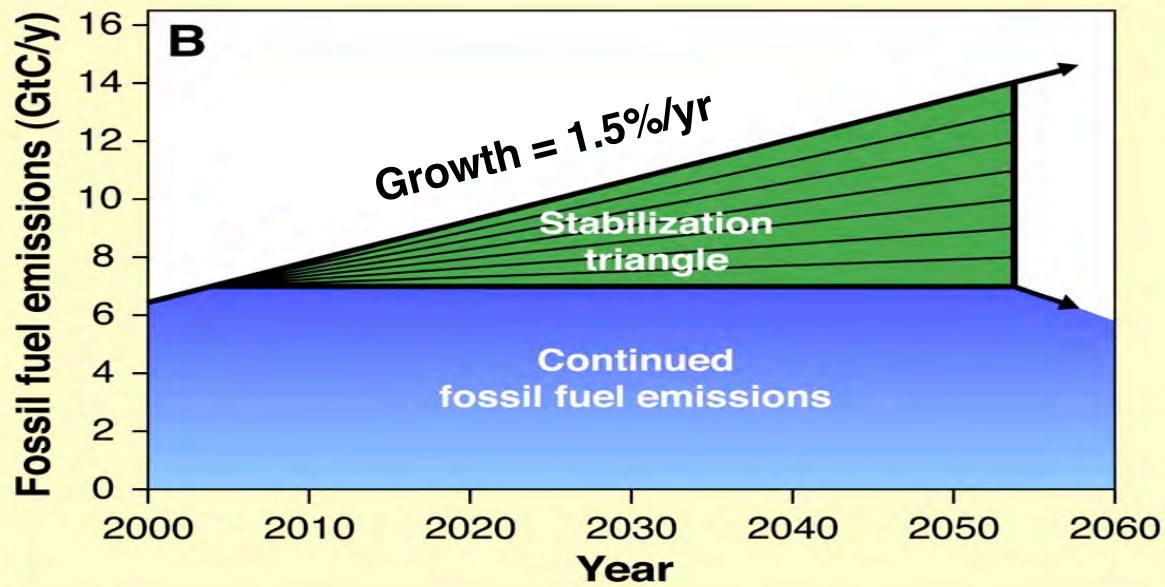
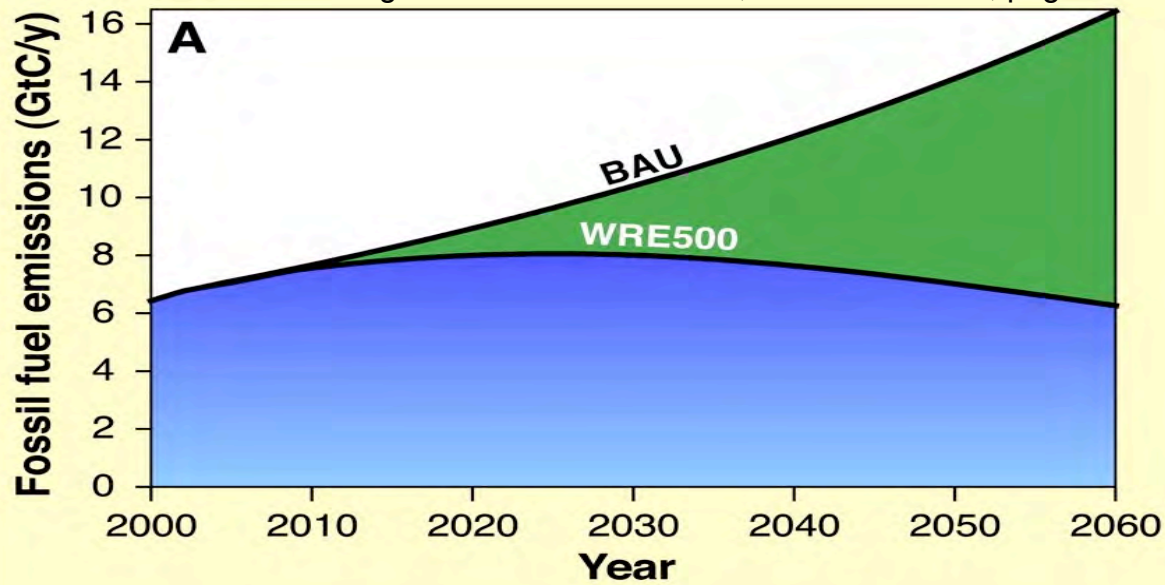
Tanzania: fruit seller - flame [left]; 1-watt white LED [right]

Productive uses: big market driver



Tanzania: shoe seller - flame [left]; 1-watt white LED [right]

Source: Stabilization Wedges: Pacala and Socolow, Science Vol 305, page 968



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